SCIENCE

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*THE PROGRESS OF SCIENCE.**

A CONSTITUTIONAL provision of our Association stipulates that "it shall be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided." Happily for those of us who must in turn fulfill this duty, the scientific foresight of our predecessors set no metes and bounds with respect to the subject-matter or the mode of treatment of the theme that might be chosen for such an address. So far, therefore, as constitutional requirements are concerned, a retiring president finds himself clothed for the time being with a degree of liberty which might be regarded as dangerous, were it not for an unwritten rule that one may not hope to enjoy such liberty more that once. But time and place, nevertheless, as well as the painful personal limitations of any specialist, impose some rather formidable restrictions. One may not tax lightly, even in a summer evening, the patience of his audience for more than an academic hour, the length of which in most cases is less than sixty minutes. One must confine himself to generalities, which, though scientifically hazardous, serve as a basis for semi-popular thought; and one must exclude technical

* Address of the president of the American Association for the Advancement of Science, given at the Denver Meeting, August 27, 1901.

details, which, though scientifically essential, tend only to obscure semi-popular presentation. Courtesy, also, to those who are at once our hosts and our guests requires that, so far as possible, one should substitute the vernacular for the 'jargon of science,' and draw his figures of speech chiefly from the broad domain of every-day life rather than from the special, though rapidly widening, fields of scientific activity.

Between this nominally unlimited freedom on the one hand, and these actually narrow restrictions on the other, I have chosen to invite your attention for the hour to a summary view of the salient features of scientific progress, with special reference to its effects on the masses, rather than on the individuals, of mankind. We all know, at least in a general way, what such progress is. We are assured almost daily by the public press and by popular consent that the present is not only an age of scientific progress, but that it is preeminently the age of scientific progress. And with respect to the future of scientific achievement, the consensus of expert opinion is cheerfully hopeful, and the consensus of public opinion is extremely optimistic. Indeed, to borrow the language sometimes used by the rulers of nations, it may be said that the realm of science is now at peace with all foreign parts of the world, and in a state of the happiest domestic prosperity.

But times have not been always thus pleasant and promising for science. As we look backward over the history of scientific progress it is seen that our realm has been taxed often to the utmost in defense of its autonomy, and that the present state of domestic felicity, bordering on tranquility, has been preceded often by states of domestic discord bordering on dissolution. And, as we look forward into the new century before us, we may well enquire whether science has vanquished its foreign enemies and settled its domestic disputes for good and all, or whether future conquests can be made only by a similarly wasteful outlay of energy to that which has accompanied the advances of the past. Especially may we fitly enquire on an occasion like the present what are the types of mind and the methods of procedure which make for the progress, and what are the types of mind and the methods of procedure which make for the regress, of science. And I venture to think that we may enquire, also with profit, in some prominent instances, under what circumstances in the past science has waxed or waned, as the case may be, in its slow rise from the myths and mysticism of earlier eras to the law and order of the present day. For it is a maxim of common parlance, too well justified, alas! by experience, that history repeats itself; or, to state the fact less gently, that the blunders and errors of one age are repeated with little variation in the succeeding age. This maxim is strikingly illustrated by the history of science, and it has been especially deeply impressed upon us—burnt in, one might say—by the scientific events of our own times. Have we not learned, however, some lasting lessons in the hard school of experience, and may we not transmit to our successors along with the established facts and principles of science the almost equally well established ways and means for the advancement of science? Will it be possible for society to repeat in the twentieth century the appalling intellectual blunders of the nineteenth century, or have we entered on a new era in which, whatever other obstacles are pending, we may expect man to stand notably less in his own light as regards science than ever before? To a consideration of these and allied questions I beg your indulgence, even though I may pass over ground well known to most of you, and encroach, perhaps, here and there, on prominences in fields controversial; for it is only by discussion and rediscussion of such questions

that we come at last, even among ourselves in scientific societies, to the unity of opinion and the unity of purpose which lead from ideas to their fruitful applications.

From the earliest historic times certainly, if not from the dawn of primitive humanity, down to the present day, the problem of the universe has been the most attractive and the most illusive subject of the attention of thinking men. All systems of philosophy, religion and science are alike in having the solution of this problem for their ultimate object. Many such systems and sub-systems have arisen, flourished and vanished, only to be succeeded by others in the seemingly Sisyphean task. Gradually, however, in the lapse of ages there have accumulated some elements of knowledge which give inklings of partial solutions; though it would appear that the best current opinion of philosophy, religion and science would again agree in the conclusion that we are yet immeasurably distant from a complete solution. Almost equally attractive and interesting, and far more instructive, as it appears to me, in our own time, is the contemplation of the ways in which man has attacked this perennial riddle. It is, indeed, coming to be more and more important for science to know how primitive, barbarous and civilized man has visualized the conditions of, and reached his conclusions with respect to, this problem of the centuries; for it is only by means of a lively knowledge of the baseless hypotheses and the fruitless methods of our predecessors that we can hope to prevent history from repeating itself unfavorably.

Looking back over the interval of two to three thousand years that connects us by more or less authentic records with our distinguished ancestors, we are at once struck by the admirable confidence they had acquired in their ability to solve this grand problem. Not less admirable, also, for their ingenuity and for the earnestness with which they were advanced, are the hypotheses and arguments by which men satisfied themselves of the security of their tenets and theories. Roughly speaking, it would appear that the science of the universe received its initial impulse from earliest man in the hypothesis that the world is composed of two parts; the first and most important part being in fact, if not always so held ostensibly, himself, and the other part being the aggregate of whatever else was left over. Though dimly perceived and of little account in its effects, this is, apparently, the working hypothesis of many men in the civilized society of to-day. But the magnitude of the latter part and its inexorable relations to man seem to have led him speedily to the adoption of a second hypothesis, namely, that the latter part, or world external to himself, is also the abode of sentient beings, some of a lower and some of a higher order than man; their rôle tending on the whole to make his sojourn on this planet tolerable and his exit from it creditable, while yet wielding at times a more or less despotic influence over him.

How the details of these hypotheses have been worked out is a matter of something like history for a few nationalities, and is a matter absorbing the attention of anthropologists, archeologists and ethnologists as it concerns races in general. Without going far afield in these profoundly interesting and instructive details, it may suffice for the present purposes to cite two facts which seem to furnish the key to a substantially correct interpretation of subsequent developments.

The first of these is that the early dualistic and antithetical visualization of the problem in question has persisted with wonderful tenacity down to the present day. The accessible and familiar was set over against the inaccessible and unfamiliar; or what we now call the natural,

though intimately related to, was more or less opposed to the supernatural; the latter being, in fact, under the uncertain sway of, and the former subject to the arbitrary jurisdiction of, good and evil spirits.

The second fact is that man thus early devised for the investigation of this problem three distinct methods, which have likewise persisted with equal tenacity, though with varying fortunes, down to the present day. The first of these is what is known as the à priori method. It reasons from subjective postulates to objective results. It requires, in its purity, neither observation nor experiment on the external world. It often goes so far, indeed, as to adopt conclusions and leave the assignment of the reasons for them to a subsequent study. The second is known as the historico-critical method. It depends, in its purity, on tradition, history, direct human testimony and verbal congruity. It does not require an appeal to Nature except as manifested in man. It limits observation and experiment to human affairs. The third is the method of science. It begins, in its elements, with observation and experiment. Its early applications were limited mostly to material things. In its subsequent expansion it has gained a footing in nearly every field of thought. Its prime characteristic is the insistence on objective verification of its results.

All these methods have been used more or less by all thinking men. But for the purposes of ready classification it may be said that the first has been used chiefly by dogmatists, including especially the founders and advocates of all fixed creeds from the atheistic and the pantheistic to the theistic and the humanistic; the second has been used chiefly by humanists, including historians, publicists, jurists and men of letters; and the third has been used chiefly by scientists, including astronomers, mathematicians, physicists, naturalists, and more recently the group of investigators falling under the comprehensive head of anthropologists. The first and third methods are frequently found to be mutually antithetical, if not mutually exclusive. The second occupies middle ground. Together they are here set down in the order of their apparent early development and in the order of their popularly esteemed importance during all historic time previous to, if not including, this first year of the twentieth century.

No summary view of the progress of science, it seems to me, can be made intelligible except by a clear realization of these two facts, which may be briefly referred to as man's conception of the universe and his means of investigating it. What, then, in the light of these facts, has been the sequel? The full answer to this question is an old and a long story, now a matter of minute and exhaustive history as regards the past twenty centuries. I have no desire to recall the dramatic events involved in the rise of science from the Alexandrian epoch to the present day. All these events are trite enough to men of science. A mere reference to them is a sufficient suggestion of the existence of a family skeleton. But, setting aside the human element as much as possible, it may not be out of place or time to state what general conclusions appear to stand out plainly in that sequel. These are our tangible heritage and upon them we should fix our attention.

In the first place, the progress of science has been steadily opposed to, and as steadily opposed by, the adherents of man's primitive concepts of the universe. The domain of the natural has constantly widened and the domain of the supernatural has constantly narrowed. So far, at any rate, as evil spirits are concerned, they have been completely cast out from the realm of science. The arch fiend and the lesser princes of darkness are no longer useful even as an hypothesis. We have reached—if I may again use the cautious

language of diplomacy—a satisfactory modus vivendi if we have not attained permanent peace in all our foreign relations. Enlightened man has come to see that his highest duty is to cooperate with Nature, that he may expect to get on very well if he heeds her advice, and that he may expect to fare very ill if he disregards it.

Secondly, it appears to have been demonstrated that neither the à priori method of the dogmatists nor the historico-critical method of the humanists is alone adequate for the attainment of definite knowledge of either the internal or the external world, or of their relations to one another. In fact, it has been shown over and over again that man cannot trust his unaided senses even in the investigation of the simplest and most obvious material phenomena. There is an ever-present need of a correction for personal equation. Left to himself, the à priori reasoner weaves from the tangled skein of thought webs so well tied by logical knots that there is no escape for the imprisoned mind except by the rude process applied to cobwebs. And in the serenity of his repose behind the fortress of 'liberal culture,' the reactionary humanist will prepare apologies for errors and patch up compromises between traditional beliefs and sound learning with such consummate literary skill that even 'the good demon of doubt' is almost persuaded that if knowledge did not come to an end long ago it will soon reach its limit. In short, we have learned, or ought to have learned, from ample experience, that in the search for definite, verifiable knowledge we should beware of the investigator whose equipment consists of a bundle of traditions and dogmas along with formal logic and a facile pen; for we may be sure that he will be more deeply concerned with the question of the safety than with the question of the soundness of scientific doctrines.

Thirdly, it has been demonstrated equally clearly, and far more cogently, that the sort of knowledge we call scientific, knowledge which has in it the characteristics of immanence and permanence, is founded on observation and experiment. The rise and growth of every science illustrate this fact. Even pure mathematics, commonly held to be the à priori science par excellence, and sometimes called 'the science of necessary conclusions,' is no exception to the rule. Those who would found mathematics on a higher plane have apparently forgotten to consider the contents of the mathematician's waste-basket. The slow and painful steps by which astronomy has grown out of astrology and chemistry out of alchemy; and the faltering, tedious, and generally hotly contested, advances of geology and biology have been made secure only by the remorseless disregard which observational and experimental evidence has shown for the foregone conclusions of the dogmatists and the literary opinions of the humanists. Thus it has been proved by the rough logic of facts and events that the rude processes of 'trial and error,' processes which many philosophers and some men of science still affect to despise, are the most effective means yet devised by man for the discovery of truth and for the eradication of error.

These facts are so well known to most of you, so much a matter of ingrained experience, that the categorical mention of them here may seem like a rehearsal of truisms. But it is one of the paradoxes of human development that errors which have been completely dislodged from the minds of the few may still linger persistently in the minds of the many, and that the misleading hypotheses and the dead theories of one age may be resuscitated again and again in succeeding ages. Thus, to cite one of the simplest examples, it doubtless appeared clear to the Alexandrian school of scientists that the flat, four-cornered earth of contemporary myths would speedily give way

to the revelations of geometry and astronomy. How inadequate such revelations proved to be at that time is one of the most startling disclosures in all history. The 'Divine School of Alexandria' passed into oblivion. The myth of a flat and four-cornered earth was crystallized into a dogma strong enough to bear the burden of men's souls by Cosmas Indicopleustes in the sixth century; it was supported with still more invincible arguments by Martin Luther in the sixteenth century; and it was revived and maintained with not less truly admirable logic, as such, by John Hampden and John Jasper in the last decades of the nineteenth century. To cite examples from contemporary history showing how difficult it is for the human mind to get above its primitive conceptions, one needs only to refer to the daily press. During the past two months, in fact, the newspapers have related how multitudes of men, women and children, many of them suffering from loathsome if not contagious diseases, have visited a veritable middle-age shrine in the city of New York, strong in the hoary superstition that kissing an alleged relic of St. Anne would remove their afflictions. During the same interval a railway circular has been distributed explaining how tourists may witness the Moki snake-dance, that weird ceremony by which the Pueblo Indian seeks to secure rain in his desert; and a similar public, and officially approved, ceremony has been observed in the heat-stricken State of Missouri.

Such epochs and episodes of regression as these must be taken into account in making up an estimate of scientific progress. They show us that the slow movement upward in the evolution of man which gives an algebraic sum of a few steps forward per century is not inconsistent with many steps backward. Or, to state the case in another way, the rate of scientific advance is to be measured not so much by the positions gained and held by individuals, as by the positions attained and realized by the masses, of our race. The average position of civilized man now is probably below the mean of the positions attained by the naturalist Huxley and the statesman Gladstone, or below the mean of the positions attained by the physicist von Helmholtz and His Holiness the Pope. When measured in this manner, the rate of progress in the past twenty centuries is not altogether flattering or encouraging to us, especially in view of the possibility that some of the more recently developed sciences may suffer relapses similar to those which so long eclipsed geography and astronomy.

It must be confessed, therefore, when we look backward over the events of the past two thousand years, and when we consider the scientific contents of the mind of the average denizen of this planet, that it is not wholly rational to entertain millennial anticipations of progress in the immediate future. The fact that some of the prime discoveries of science have so recently appeared to many earnest thinkers to threaten the very foundations of society is one which should not be overlooked in these confident times of prosperity. And the equally important fact that entire innocence with respect to the elements of science and dense ignorance with respect to its methods, have not been hitherto incompatible with justly esteemed eminence in the divine, the statesman, the jurist and the man of letters, is one which should be reckoned with in making up any forecast. It may be seriously doubted, indeed, whether the progress of the individual is not essentially limited by the progress of the race.

But this obverse and darker side of the picture which confronts us from the past has its reverse and brighter side; and I am constrained to believe that the present status of science and the general enlightenment

of humanity justify ardent hopefulness if not sanguine optimism with respect to the future of scientific achievement. The reasons for this hopefulness are numerous; some of them arising out of the commercial and political conditions of the world, and others arising out of the conditions of science itself.

Perhaps the most important of all these reasons is found in the general enlargement of ideas which has come, and is coming, with the extension of trade and commerce to the uttermost parts of the earth. We are no longer citizens of this or that country, simply. Whether we wish it or not we are citizens of the world, with increased opportunities and with increased duties. We may not approve—few men of science would approve, I think—that sort of 'expansion' which works 'benevolent assimilation' of inferior races by means of a bible in one hand and a gun in the other; but nothing can help so much, it seems to me, to remove the stumbling blocks in the way of the progress of science as actual contact with the manners, the customs, the relations and the resulting questions for thought, now thrust upon all civilized nations by the events of the day. That sort of competition which is the life of trade, that sort of rivalry which is the stimulus to national effort, and that sort of cooperation which is essential for mutual protection, all make for the cosmopolitan dissemination of scientific truth and for the appreciation of scientific investigation. I would not disparage the elevated aspirations and the noble efforts of the evangelists and the humanists who seek to raise the lower to the plane of the higher elements of our race; but it is now plain as a matter of fact, however repulsive it may seem to some of our inherited opinions, that the railway, the steamship, the telegraph and the daily press will do more to illumine the dark places of the earth than all the apostles of creeds and all the messengers of the gospel of 'sweetness and light.'

A question of profound significance growing out of the extension of commercial relations in our time is what may be called the question of international health. An outbreak of cholera in Hamburg, the prevalence of yellow fever in Havana, or an epidemic of bubonic plague in India is no longer a matter of local import, as nations with which we are well acquainted have learned recently in an expensive manner. The management of this great international question calls for the application of the most advanced scientific knowledge and for the most intricate scientific investigation. Large sums of money must be devoted to this work, and many heroic lives will be lost, doubtless, in its execution; but it is now evident, as a mere matter of international political economy, that the cost of sound sanitation will be trifling in comparison with the cost of no sanitation; while further careful study of the natural history of diseases promises practical immunity from many of them at no distant day. International associations of all kinds must aid greatly also in the promotion of progress. Many such organizations have, indeed, already undertaken scientific projects with the highest success. Comparison and criticism of methods and results not only lead rapidly and effectively to improvements and advances, but they lead also to a whole-hearted recognition of good work which puts the fraternalism of men of science on a plane far above the level of the amenities of merely diplomatic life.

When we turn to the general status of science itself, there is seen to be equal justification for hopefulness founded on an abundance of favorable conditions. The methods of science may be said to have gained a footing of respectability in almost every department of thought, where, a half-century ago, or even twenty years ago,

their entry was either barred out or stoutly opposed. The 'Conflict between Religion and Science'—more precisely called the conflict between theology and science—which disturbed so many eminent though timid minds, including not a few men of science, a quarter of a century ago, has now been transferred almost wholly to the field of the theological contestants; and science may safely leave them to determine the issue, since it is evidently coming by means of scientific methods. The grave fears entertained a few decades ago by distinguished theologians and publicists as to the stability of the social fabric under the stress put upon it by the rising tide of scientific ideas, have not been realized. And, on the other hand, the grave doubts entertained by distinguished men of science a few decades ago as to the permeability and ready response of modern society to that influx of new ideas, have likewise not been realized. It is true that we still sometimes read of theological tests being applied to teachers of biology, and hear, occasionally, of an earnest search for a good methodist or a good presbyterian mathematician; but such cases may be left for settlement out of court by means of the arbitration of our sense of humor. It seems not unlikely, also, that there may persist, for a long time to come, a more or less guerilla 'warfare of science' with our friends the dogmatists and the humanists. Some consider this conflict to be, in the nature of things, irrepressible. But I think we may hope, if we may not confidently expect, that the collisions of the future will occur more manifestly than they have in the past in accordance with the law of the conservation of energy; so that the heat evolved may reappear as potential energy in the warmth of a kindly reasonableness on both sides, rather than suffer degradation to the level of cosmic frigidity.

Great questions, also, of education, of economic, industrial and social conditions, and of legal and political relations are now demanding all the light which science can bring to bear upon them. Though tardily perceived, it is now admitted, generally, that science must not only participate in the development of these questions but that it alone can point the way to the solutions of many of them. But there is no halting ground here. Science must likewise enter and explore the domain of manners and morals; and these, though already largely modified unconsciously, must now be modified consciously to a still greater extent by the advance of science. Only within quite recent times have we come to realize an approximation to the real meaning of the trite saying that the proper study of man is man. So long as the most favored individuals of his race, in accordance with the hypothesis of the first centuries, looked upon him as a fallen, if not a doomed, resident of an abandoned reservation, there could be roused little enthusiasm with respect to his present condition; all thought was concentrated on his future prospects. How incomparably different does he appear to the anthropologist and the psychologist at the beginning of the twentieth century! In the light of evolution he is seen to be a part of, and not apart from, the rest of the universe. The transcendent interest of this later view of man lies in the fact that he can not only investigate the other parts of the universe, but that he can, by means of the same methods, investigate himself.

I would be the last to look upon science as furnishing a speedy or a complete panacea for the sins and sorrows of mankind; the destiny of our race is entangled in a cosmic process whose working is thus far only dimly outlined to us; but it is nevertheless clear that there are available to us immense opportunities for the betterment of man's estate. For example, to mention only one of the lines along which improvement is

plainly practicable, what is to hinder an indefinite mitigation, if not a definite extinction, of the ravages of such dread diseases as consumption and typhoid fever? Or what, we may ask, is to hinder the application to New York, Philadelphia and Chicago of as effective health regulations as those now applied to Havana? Nothing, apparently, except vested interests and general apathy. We read, not many years ago, that a city of about one million inhabitants had, during one year, more than six thousand cases of typhoid fever. The cost to the city of a single case may be estimated as not less, on the average, than one thousand dollars, making an aggregate cost to that city, for one year, of more than six millions of dollars. Such a waste of financial resources ought to appeal to vested interests and general apathy even if they cannot be moved by any higher motives. Thanks to the penetration of the enlightenment of our times, distinct advances have already been made in the line of effective domestic and public sanitation; but the good work accomplished is infinitesimal in comparison with that which can be, and ought to be, done. It is along this and along allied lines of social and industrial economy that we should look, I think, for the alleviation of the miseries of mankind. No amount of contemplation of the beatitudes, human or divine, will prevent men from drinking contaminated water or milk; and no fear of future punishments, which may be in the meantime atoned for, will much deter men from wasting their substance in riotous living. The moral certainty of speedy and inexorable earthly annihilation is alone adequate to bring man into conformity with the cosmic rules and regulations of the drama of life.

And finally we must reckon amongst the most important of the conditions favorable to the progress of science, the unexampled activity in our times of the scientific spirit as manifested in the work of all kinds of organizations, from the semi-religious Chautauquan assemblies up to those technical societies whose programs are Greek to all the world beside. Literature, linguistics, history, economics, law and theology are now permeated by the scientific spirit if not animated by the scientific method. Curiously enough, also, the terminology, the figures of speech and the points of view of science are now quite common in realms of thought hitherto held somewhat scornfully above the plane of materialistic phenomena. Tyndall's Belfast address, which, twenty-seven years ago, was generally anathematized, is now quoted with approval by some of the successors of those who bitterly denounced him and all his kind. Thus the mere lapse of time is working great changes and smoothing out grave differences of opinion in favor of the progress of science in all the neighboring provinces with which we have been able hitherto to maintain only rather strained diplomatic relations.

Still more immediately important to us are the evidences of progress manifested in recent years by this Association and by its affiliated societies. Our parent organization, though a half century old, is still young as regards the extent in time of the functions it has undertaken to perform. It has accomplished a great work; but in the vigor and enthusiasm of its youth a far greater work is easily attainable. Exactly how these functions are to be developed, no man can foresee. We may learn, however, in this, as in other lines of research, by methods with which we are well acquainted, namely, by the methods of carefully planned and patiently executed observation and experiment. The field for energetic and painstaking effort is wider and more attractive than ever before. Science is now truly cosmopolitan; it can be limited by no close corporations; and no domain of scientific

investigation can be advantageously fenced off, either in time or in space, from the rest. While every active worker of this or of any affiliated society is, in a sense, a specialist, there are occasions when he should unite with his colleagues for the promotion of the interests of science as a whole. The results of the specialists need to be popularized and to be disseminated among the people at large. The advance of knowledge, to be effective with the masses of our race, must be sustained on its merits by a popular verdict. To bring the diverse scientific activities of the American Continent into harmony for common needs; to secure cooperation for common purposes; and to disseminate the results of scientific investigation among our fellow-men, are not less, but rather much more, than in the past, the privilege and the duty of The American Association for the Advancement of Science.

Viewed, then, in its broader aspects, the progress of science is involved in the general progress of our race; and those who are interested in promoting the former should be equally earnest in securing the latter. However much we may be absorbed in the details of our specialties, when we stop to think of science in its entirety, we are led, in the last analysis, back to the problem of problems—the meaning of the universe. All men 'gifted with the sad endowment of a contemplative mind' must recur again and again to this riddle of the centuries. We are, so to speak, whatever our prepossessions, all sailing in the same boat on an unknown sea for a destination at best not fully determined. Some there are who have, or think they have, the Pole Star always in sight. Others, though less confident of their bearings, are willing to assume nothing short of second place in the conduct of the ship. Others, still less confident of their bearings, are disposed to depend chiefly on their knowledge of the compass and on their skill in dead reckoning. We of the last class may not impugn the motives or doubt the sincerity of the first two classes. We should find it difficult, probably, to dispense with their company in so long a journey after becoming so well acquainted with them; for among them we may each recall not a few of those rarer individuals of the genus homo called angels on earth. But it must be said in all truth, to resume the figure, that they have neither improved much the means of transportation nor perfected much the art of navigation. They have been sufficiently occupied, perhaps, in allaying the fears of the timid and in restraining the follies of the mutinous. Other types of mind and other modes of thought than theirs have been essential to work out the improvements which separate the earlier from the later nautical equipments of men; such improvements, for example, as mark the distinction between the dug-out of our lately ackowledged relatives, the Moros and the Tagalogs, from the Atlantic liner of to-day.

At any rate, we are confronted by the fact that man's conceptions of the universe have undergone slow but certain enlargement. His early anthropocentric and anthropomorphic views have been replaced, in so far as he has attained measurable advancement, by views that will bear the tests of astronomy and anthropology. He has learned, slowly and painfully, after repeated failures and many steps backward, to distinguish, in some regions of thought, the real and the permanent from the fanciful and fleeting phenomena of which he forms a part. His pursuit of knowledge, in so far as it has led him to certainty, has been chiefly a discipline of disillusionment. He has arrived at the truth not so much by the genius of direct discovery as by the laborious process of the elimination of error. Hence he who has learned wisdom from experience must look out on the problem of the universe at the beginning of the twentieth

century, with far less confidence in his ability to speedily solve it and with far less exaggerated notions of his own importance in the grand aggregate of Nature, than man entertained at the beginning of our era. But no devotee to science finds humiliation in this departure from the primitive concepts of humanity. On the contrary, he has learned that this apparent humiliation is the real source of enlightenment and encouragement; for notwithstanding the relative minuteness of the speck of cosmic dust on which we reside, and notwithstanding the relative incompetency of the mind to discover our exact relations to the rest of the universe, it has yet been possible to measure that minuteness and to determine that incompetency. These, in brief, are the elements of positive knowledge at which we have arrived through the long course of unconscious, or only half-conscious, experience of mankind. All lines of investigation converge towards or diverge from these elements. It is along such lines that progress has been attained in the past, and it is along the same lines that we may expect progress to proceed in the future.

R. S. WOODWARD.

COLUMBIA UNIVERSITY.

ZOOLOGY OF THE TWENTIETH CENTURY.*

LOOKING over the vice-presidential addresses given before the American and British Associations during the past year or two in an eager search for suggestions, I found a prevailing tone of retrospect. The advance of science in the nineteenth century was a favorite theme, and little wonder in view of the century's marvelous events. Since by the arrangement of the council I lost my opportunity to be an end-of-the-century historian last year, I shall essay the rôle of a prophet this. On the historical side I could have given you something very interesting, I assure you. Not I, but the council that delayed my address to the following century, must be held responsible for the poor substitute I am able to present.

We have stood in retrospect at the close of the nineteenth century and marveled at what it brought forth. Here at the threshold of the twentieth century it is natural that we should wonder what it will unfold. Will the changes be as great, and in what direction will advance chiefly be made? I am the more content to consider such questions for three reasons: First, because we can use history to formulate predictions; second, because the attempt may possibly influence to some slight degree the future development of zoology; and third, because the attempt is tolerably safe, since we shall none of us know all that the century will bring forth.

Comparing the beginning of the twentieth century with that of the nineteenth, we find the most striking advances to have taken place in our morphological knowledge. The nineteenth may indeed be designated the morphological century. The demands of systematic zoology first made anatomical studies necessary. Later, comparison came to be accepted as the fundamental zoological method, and comparative anatomy, emancipated from its servitude to systematic zoology, became an independent science. Still later embryology arose, at first as a descriptive science and then as a comparative one. Out of embryology arose modern cytology, which in turn is creating a comparative histology. Partly as a result of studying embryology as a process has arisen the modern tendency toward comparative physiology. As a result of the general acceptance of the evolution doctrine, the study of the geographical distribution of organisms and of adaptations has gained a new meaning. From the great matrix of 'gen-

* Address of the Vice-president of Section F, Zoology, American Association for the Advancement of Science, Denver Meeting, August, 1901.

eral biology' there has begun to crystallize out a number of well-defined sub-sciences.

Looking broadly at the progress made during the past century, we see that zoology has become immensely more complex, due to its developing in many lines, and that the new lines are largely interpolated between the old and serve to connect them. The descriptive method has developed into a higher type—the comparative; and of late years still a new method has been introduced for the study of processes—the experimental. The search for mechanisms and causes has been added to the search for the more evident phenomena. The zoologist is no longer content to collect data; he must interpret them.

In view of the past history of our science, what can we say of its probable future? We may be sure that zoology will develop in all these three directions: (1) The continued study of old subjects by old methods; (2) the introduction of new methods of studying old subjects; and (3) the development of new subjects.

I am not of those who would belittle the old subjects, even when pursued in the old way. There is only one class of zoologist that I would wish to blot out, and that is the class whose reckless naming of new 'species' and 'varieties' serves only to extend the work and the tables of the conscientious synonomy hunter. Other than this all classes will contribute to the advancement of the science. No doubt there are unlabeled species, and no doubt they must, as things are, be named. And no doubt genera and families must be 'revised' and some groups split up and others lumped. So welcome to the old-fashioned systematist, though his day be short, and may he treat established genera gently. No doubt there are types of animals of whose structure we are woefully ignorant; no doubt we need to know their internal anatomy in great detail. So welcome to the zootomist in this new century, and may he invent fewer long names for new organs. No doubt there are groups of whose relationships we know little and which have been buffeted about from one class to another in a bewildering way. We need to have them stay fixed. So welcome to the comparative anatomist and the embryologist, and may their judgment as to the relative value of the criteria of homology grow clearer. No doubt our knowledge of inheritance and development will be immensely advanced by the further study of centrosomes, asters and chromosomes. Welcome, therefore, to the cytologist, and may he learn to distinguish coagulation products and plasmolytic changes from natural structures. All these subjects have victories in store for them in the new century. To neglect them is to neglect the foundations of zoology.

But the coming century will, I predict, see a change in the methods of studying many of these subjects. In systematic zoology fine distinctions will no longer be expressed by the rough language of adjectives, but quantitatively, as a result of measurement. There is every reason to expect, indeed, that the future systematic work will look less like a dictionary and more like a table of logarithms. Our system of nomenclature, meanwhile, will probably break down from its own weight. Now that the binomial system of nomenclature has been replaced by a trinomial, there is no reason why we should not have a quadrinomial nomenclature or even worse. It seems as if the Linnæan system of nomenclature is doomed. What will take its place can hardly be predicted. The new system should recognize the facts of place-modes and color varieties. We might establish certain categories of variation such as those of geographical regions, of habitat, of color. A decimal system of numbers might be applied to the parts of the coun-

try or the kinds of habitat, and the proper number might take the place of the varietal or subvarietal name. Thus the northeastern skunk might be designated *Mephitis mephitica* 74 and the southeastern skunk *Mephitis mephitica* 75 (adopting the Dewey system of numerals). The Maine skunk would then be 741; that of New York 747, and so on. This much for a suggestion.

So likewise for the morphologist the coming century will bring new aims and new methods. No longer will the construction of phylogenetic trees be the chief end of his studies, but a broad understanding of the form producing and the form maintaining processes. The morphologist will more and more consider experiment a legitimate method for him. The experimental method will, I take it, be extended especially to the details of cytology, and here cytology will make some of its greatest advances.

Not only will the old subjects be studied by new methods, but we have every reason to believe that new sub-sciences will arise during the twentieth century as they did during the nineteenth. Of course we cannot forecast all these unborn sciences, as cytology and neurology could hardly have been forecast at the beginning of the nineteenth century. But we can see the beginnings of what are doubtless to be distinct sciences. Thus comparative physiology is still in its infancy and is as yet hardly worthy of the name of a science; there is no question that this will develop in the coming decades. Animal behavior has long been treated in a desultory way, and many treatises on the subject are rather contributions to folk-lore than to science. But we are beginning to see a new era—an era of precise, critical and objective observation and record of the instincts and reactions of animals. One day we shall reach the stage of comparative studies, and shall have a science of the ontogeny of animal instincts. This will have the same importance for an interpretation of human behavior that comparative anatomy and embryology have for human structure.

Prominent among the advances of the century will be the ability to control biological processes. We shall know the factors that determine the rate of growth and the size of an animal, the direction and sequence of cell-divisions, the color, sex and details of form of a species. The direction of ontogeny and of phylogeny will be to a greater or less extent under our control.

The study of animals in relation to their environment, long the pastime of country gentlemen of leisure, will become a science. Some day we shall be able to say just what conditions an animal's presence at any place; and, more than that, we shall be able to account for the fauna—the sum total of animal life of any locality—and to trace the history of that fauna. This is at least one of the aims of animal ecology. It is a reproach to zoology that the subject of animal ecology should lag so far behind that of plant ecology. When zoologists fully awaken to a realization of what a fallow field lies here this reproach will quickly be wiped out. As it is, we have a notion that the factors determining the occurrence of an animal or of a fauna are too complicated to be unraveled. As a matter of fact, the factors are often quite simple. Let me illustrate this by some studies I have made this summer on the Cold Spring Beach. This beach is a spit of sand, 2,000 feet long and 50 to 75 feet broad, running from the western mainland into the harbor and ending in a point that is being made several feet a year through the cooperation of wave, tide and a silt-transporting creek of fresh water. On the outer harbor side is a broad, gradually sloping, sandy and gravelly beach, covered

by high tide and devoid of living vegetation. Above that is a narrow zone—the middle beach—covered with débris of storms, supporting a few annual plants, and bounded above by a storm-cut bluff. Above is the upper beach, covered with a perennial, sand-loving vegetation. On the lower beach the zonal distribution of animals is striking. Just above the water are found the scavenger mud snails and, further up, a crowd of *Thysanura*—small insects that rise to the surface of the water when the tide comes in. These find a living on the finer débris or silt that settles on the pebbles during the high tides. In this zone also *Limulus* lays its eggs in the sand, and its nests are crowded with nematodes that feed on the eggs. During the breeding season scores of the female *Limulus* die here, and their carcasses determine a complex fauna. First, carrion beetles (*Necrophorus*) and the flesh fly live on the dead bodies; then the robber flies and tiger-beetles are here to feed on this fauna, and finally numerous swallows course back and forward gleaning from this rich field. At the upper edge of the lower beach is a band of débris dropped at slack water and consisting especially of shreds of *Ulva* and many drowned insects, chiefly beetles. At this zone, or just above under the drier but more abundant wreckage of the last storm, occur numerous Amphipoda of the genera *Orchestia* and *Talorchestia*. Associated with these marine creatures are numerous red ants, sand-colored spiders and rove-beetles. The amphipods feed on the decaying sea-weed. The ants are here looking chiefly for the drowned insects. Their nests are further up on the middle beach, but the workers travel to the edge of the high tide to bring away their booty. The rove-beetles are general scavengers. The spiders, which are mostly of the jumping sort (of the family *Attidæ*), feed on the active insects and amphipods. At a higher zone, and above all but the storm-driven tides, one finds the nests of the ants, especially under logs, certain predaceous beetles and the xerophilous grasshoppers and crickets. Finally, on the plant-covered upper beach one finds characteristic leaf-eating beetles, grasshoppers and carnivorous insects. Now all this seems commonplace enough and not especially instructive, and yet if you go to the shore of Lake Michigan you will find on a similar beach closely similar, if not identical, forms (excepting the beach fleas and the horseshoe crabs) you will find similar ants, spiders, rove-beetles, tiger beetles and sand-grasshoppers. This fact alone shows the greater importance of habitat over geographical region in determining the assemblage of animals that occurs in any one place. It may be predicted that studies on the relation of animals to their habitat will multiply, that they will become comparative and that the science of animal ecology will become recognized as no less worthy and no less scientific than the science of morphology.

Studies on the origin of species were far from being unknown in the nineteenth century, but they were for the most part fragmentary, or speculative, or narrow in view. The opinion that there was one method of evolution seemed to hold sway. It seems to me that the signs of the times indicate that we are about to enter upon a thorough, many-sided, inductive study of this great problem, and that there is a willingness to admit that evolution has advanced in many ways. The attempt, therefore, to explain all specific peculiarities on the ground of natural selection, or on the ground of self-adjustment, or on the ground of sport preservation through isolation, we may expect equally to prove futile. All these causes are no doubt real in some cases, but to exclude any one or to deny that new causes may be found in the future is equally dangerous and unscientific.

It is often said that the factors of evo-

lution are inheritance and variation. In the new century careful and quantitative studies will be made on these factors. We shall get at quantitative expressions of the more complicated forms of heritage in the same way as Galton has given us an expression of a simple form of inheritance. We shall hope to understand why some qualities blend and others refuse to do so. We shall learn the laws of mingling of qualities in hybrids and get an explanation of the monstrosities and the sterility which accompany hybridization. What we call reversion and prepotency will acquire a cytological explanation, and it may be that the theory of fertilization will be seriously modified thereby. When we can predict the outcome of any new combination of germ plasms then, indeed, we shall have got at the laws of inheritance.

As for the other factor, that of variation, I anticipate interesting developments in our knowledge of its laws and of its causes. The methods by which this knowledge is to be acquired are doubtless comparative observation, experimentation and a quantitative study of results. Within the last decade a profound student of variation (Bateson) has declined to discuss its causes, holding that we had no certain knowledge of them. Even the categories of variation are still unenumerated. The science of variation is therefore one of those that we may hope to see established in this century. I feel convinced that statistical studies are first of all necessary to lay the foundations of the science.

As an illustration of an application of statistics to evolution studies I will give some account of my work during the past two years on the scallop of our east coast, *Pecten irradians*.

Pecten irradians is a bivalve mollusc of flattened, lenticular form, that inhabits our coast from Cape Cod southward. The Cape Cod limit is a rather sharp one, but southward our scallop passes gradually into the closely related forms of the South American coast. This fact would seem to indicate its southerly origin. To get light on the evolution of the group, I have studied and measured over 3,000 shells, chiefly from four localities: (1) Cold Spring Harbor, Long Island; (2) Morehead, North Carolina; (3) Tampa, Florida, and (4) the late Miocene or early Pliocene fossils of the Nansemond River. The fossil shells, to which I shall frequently refer, were found imbedded in the sand at Jack's Bank, one mile below Suffolk, Virginia. The bank rises to a height of 25 to 30 feet. Shells were obtained from three layers, respectively, one foot, six feet and 15 feet above the base of the bluff. Of course, the upper shells lived later than the lower ones and may fairly enough be assumed to be their direct descendants. The time interval between the upper and lower levels cannot be stated. As I have measured sufficient shells from the bottom and top layers only I shall consider them chiefly. I wished to get recent *Pectens* from this locality, but the nearest place where they occur in quantity is Morehead, North Carolina. These *Pectens* may therefore stand as the nearest recent descendants of the *Pectens* of the Nansemond River.

The *Pecten* shells have a characteristic appearance in each of the localities studied. After you have handled them for some time you can state in 95 per cent. of the cases the locality from which any random shell has come. First of all, the shells differ in color, especially of the lower valve. In the specimens from Cold Spring Harbor this is a dirty yellow; from Morehead, yellow to salmon; from Tampa white through clear yellow to bright salmon. Second, the antero-posterior diameter of the shell becomes relatively greater than the vertical diameter as you go north. Thus, the antero-posterior diameter exceeds, on the average, the dorso-

ventral diameter: at Tampa, by about 1.5 mm.; at Morehead, 2.5 mm.; and at Cold Spring Harbor, 6 mm. The fossil *Pectens* have an excess of about 4 mm.

Comparing the fossils with the *Pectens* of Morehead we find, as shown above, that the fossils are more elongated. Comparing the depth of the right valves having a height of 59 mm., we get:

From the lowest level, Jack's Bank	8.8 mm.
" " highest " " "	9.1 mm.
" Morehead	19.7 mm.

Hence the recent shells are much more nearly spherical than the fossils; there is a phylogenetic tendency toward increased globosity.

The average number of rays in the different localities is as follows:

Lower level, Jack's Bank	22.6
Middle " " "	22.1
Upper " " "	21.7
Morehead and Cold Spring Harbor	10.3
[Tampa	20.5]

Here it appears that there is a phylogenetic tendency toward a decrease in the number of rays of *Pecten irradians*. To summarize: The scallop is becoming, on the average, more globose, and the number of its rays is decreasing and its valves are probably becoming more exactly circular in outline. The foregoing examples illustrate the way in which quantitative studies of the individuals of a species can show the change in its average condition both at successive times and in different places.

But the quantitative method yields more than this. It is well known that if the condition of an organ is expressed quantitatively in a large number of individuals of a species the measurements or counts made will vary, *i. e.*, they will fall into a number of *classes*. The proportion of individuals falling into a class gives what is known as the 'frequency' of the class. Now it appears that in many cases the middle class has the greatest frequency (and is consequently called the mode) and as we depart from it the frequency gradually diminishes, and diminishes equally at equal distances above and below the mode. One can plot the distribution of frequencies by laying off the successive classes at equal intervals along a base line and drawing perpendiculars at these points proportional in length to the frequency. If the tops of these perpendiculars be connected by a line there is produced a 'frequency polygon.' The shape of the frequency polygon gives much biological information. When the polygon is symmetrical about the model ordinate we may conclude that no evolution is going on; that the species is at rest. But very often the polygon is more or less unsymmetrical or 'skew.' A skew polygon is characterized by this: that the polygon runs from the mode further on one side than on the other. This result may clearly be brought about by the addition of individuals to one side or their subtraction from the other side of the normal frequency polygon. The direction of skewness is toward the excess side. The skew frequency polygon indicates that the species is undergoing an evolutionary change. Moreover, the direction and degree of skewness may tell us something of the direction and rate of that change. There is one difficulty in interpretation, however, for a polygon that is skew may be so either from innate or from external causes. In the case of skewness by addition we may think that there is an innate tendency to produce variants of a particular sort, representing, let us say, the *atavistic* individuals. In this case skewness points to the past. The species is evolving *from* the direction of skewness. In the case of skewness by subtraction there are external causes annihilating some of the individuals lying at one side of the mode. Evolution is clearly occurring away from that side and *in* the direction of skewness.

Now so far as we know at the present time there is no way of distinguishing skew polygons due to atavism from such as are due to selective annihilation. But in many cases at least the skewness, especially when slight, can be shown to be due to atavism; and this is apparently the commoner cause. This conclusion is based first upon a study of races produced experimentally and whose ancestry is known, and secondly upon certain cases of compound curves. Take the case of the ray flowers of the common white daisy. A collection of such daisies gathered in the fields by DeVries gave a mode of 13 ray flowers with a positive skewness of 1.2. The 12- or 13-rayed wild plants were selected to breed from, and their descendants, while maintaining a mode at 13, had the increased positive skewness of 1.9. The descendants of the 12-rayed parents had a stronger leaning towards the high ancestral number of ray flowers than the original plants had. The 21-rayed plants were also used to breed from. Their descendants were above the ancestral condition as the descendants of the 12-rayed plants were below. The skewness — 0.13 is comparatively slight. In this case we have experimental evidence that polygons may be skew *toward* the original ancestral condition.

Of the compound polygons it is especially the bimodal polygon that frequently gives hint of two races arising out of one ancestral, intermediate condition. Consequently we should expect the two constituent polygons to be skew in opposite directions; and so we usually find them to be. For example, Bateson has measured the horns on the heads of 343 rhinoceros beetles and has got a bimodal polygon. The polygon with the lower mode has a skewness of + 0.48; that with the higher mode a skewness of — 0.03. One might infer that the right-hand form, the long-horned beetles, had diverged less than the short-horned from the ancestral condition. Again, as is well known, the chinch bug occurs in two forms—the long-winged and the short-winged. Now, in a forthcoming paper my pupil, Mr. Garber, will show that the frequency polygon of the short-winged form has a skewness of + 0.44, while that of the long-winged form has a skewness of — 0.43. On our fundamental hypothesis the ancestral condition must have been midway between the modes.

Still a third class of cases that gives evidence as to the significance of skewness is that where two place modes have moved in the same direction but in different degrees. Thus the index (breadth ÷ length) of the shell of *Littorina littorea*, the shore snail, as measured by Bumpus, has at Newport a mode of 90, at Casco Bay of 93. The skewness is positive in both places and greater (+ .24) at the more southern point than at Casco Bay (+ .13). This indicates that the ancestral races had a higher index even than those of Casco Bay, probably not far from 96, and also that the *Littorina littorea* of our coast came from the northward, since the northern shells are the rounder. We have historical evidence that they did come from the northward. Likewise the *Littorinas* from South Kincardineshire, Scotland, have a modal index of 88 and a skewness of + 0.065, while those of the Humber, with a mode of 91 have a skewness of + 0.048. These figures suggest that if the mode were 97 the skewness would be 0, and this would give practically the same value to the ancestral index as arrived at for the *Littorinas* of our coast. It will be seen from these illustrations that the form of the frequency polygon may be of use in determining phylogeny.

While skewness is thus often reminiscent, we must not forget the possibility that it may be, in certain cases, prophetic. This has come out rather strongly in a piece of

work I have been engaged on during the past year. I have been counting the number of rays in recent *Pecten irradians* from various localities and have obtained in some cases evident skewness in the frequency polygons. To see what phylogenetic meaning, if any, this skewness has I sought to get a series of late fossils. After careful consideration I was led to go to the Nansemond River for the late Tertiary fossils found there and already referred to. These served my purpose admirably. We may now compare the average number of rays from the two extreme layers at Jack's Bank and at Morehead with the indices of skewness of the frequency polygons from the same localities.

Place.	Avg. No. of Rays.	Index of Skewness.	σ
Morehead, N. C.	17.3	—0.09	0.81
Upper Layer, Jack's Bank.	21.7	—0.16	1.0
Lower Layer, Jack's Bank.	22.6	—0.22	1.24

This series is instructive in that it tells us that the gradual reduction in the number of rays has been accompanied at each preceding stage by a negative skewness. This skewness was thus *prophetic* of what was to be. The skew condition of the frequency polygon we may attribute to a selection taking place at every stage, and the interesting result appears that the selection diminishes in intensity from the earliest stage onward. It is as though perfect adjustment were being acquired. If adjustment were being perfected we might expect a decrease in the *variability* in the rays at successive periods. And we do find such a decrease. This is indicated in the last column where σ stands for the index of variability. From this column it appears that the variation in the number of rays has diminished from 1.24 rays in the Miocene to 0.81 rays in recent times. This fact again points to an approach to perfection and stability on the part of the rays. Just why or wherein the reduced number of rays is advantageous I shall not pretend to say. It is quite possible that it is not more advantageous, but that there is in the phylogeny of *Pecten irradians* an inherent tendency towards a reduction in the number of multiple parts. As a matter of fact there are other *Pectens* in which the number of rays is less even than in *irradians*.

The reduction in the variability of the rays with successive geological periods has another interest in view of the theory of Williams and of Rosa, according to which evolution and differentiation have of necessity been accompanied by a reduction in variability. Evolution consists, indeed, of a splitting off of the extremes of the range of variation, so that in place of species with a wide range of variability we have two or three species each with a slight range of variability. In the particular case in hand, however, it is not certain that the lower Jack's Bank form-unit (named *Pecten eboreus* by some one) has given rise to any other form than something of which *Pecten 'irradians'* of Morehead is a near representative. The evidence indicates that the reduced variability is solely the effect of the skewing factors.

The upshot of this whole investigation into the biological significance of skew variation is then this: Skewness is sometimes reminiscent and sometimes prophetic. In our present state of knowledge it is not possible by inspecting a single skew curve to say which of the two interpretations is correct in the given case. But by a comparison of the frequency curves of allied form-units the state of affairs can usually, as in the examples given, be inferred. A method of interpreting the single skew curve is a discovery for the future.

I realize that I have been bold, not to say rash, in this attempt to forecast the zoology of the twentieth century. I suppose,

after all, I have merely expressed my personal ideals. Let those comfort themselves, therefore, who like my picture not and let them draw one more to their taste. These matters of detail are after all less important; but the general trend of the science I believe to be determined by the great general laws that will hold, whatever the detailed lines of development. First, students of the science will cling closer to inductive methods without abandoning deduction. Speculative web-spinning will be less common, will be less attractive, and will be more avoided by naturalists of repute. Great generalizations will be made, of course, but made with caution and founded at every step on facts. Second, the science will deal more with processes and less with static phenomena, more with causes and less with the accumulation of data. The time is coming when the naturalist who merely describes what he sees in his sections will have neither more nor less claim for consideration than he who describes a new variety of animal. It is relations, not facts, that count. Third, the science will become experimental, at least in so far as it deals with processes. Nothing will be taken for granted that can be experimentally tested. Better experimental laboratories will be founded and larger experimental stations, such as Bacon foresaw in the new world, will be established. Fourth, the science will become more quantitative. This is the inexorable law of scientific progress, at least where processes are concerned. I repeat that there is no reason to expect or desire the abandoning of the lines of work already recognized and followed for a half century or more. Rather holding fast to and extending the old lines of investigation, zoology will be enriched by new fields of study lying between and uniting the old. As chemistry and physics are uniting and occupying the intervening field, as geology and botany are coming close together in plant ecology, so will zoology and mathematics, zoology and geology, zoology and botany find untouched fields between them and common to them. Working in these new fields and by the aid of new methods, the naturalist of the future will penetrate further into the nature of processes and unravel their causes.

The zoology of the twentieth century will be what the zoologist of the twentieth century makes it. One hundred years ago the prerequisites of the naturalist were few and the opportunities of getting them were small. He must have studied with some master or have worked as an assistant under a naturalist in some museum. The places were few, the masters often difficult of approach. Now while, on the one hand, the training required in vastly more exacting, on the other hand, the opportunities are generous. Just because of the fact that zoology is spreading to and overlapping the adjacent sciences, the zoologist must have his training broadened and lengthened. A zoologist may well be expected to know the chief modern languages (let us hope this requirement may not be further extended), mathematics through analytics, laboratory methods in organic as well as inorganic chemistry, the use of the ordinary physical instruments, advanced geology and physiography, botany, especially in its ecological, physiological and cytological aspects, and animal paleontology. The list of prerequisites is appallingly long; zoologists of the future will be forced to an earlier and narrower specialization, while at the same time they must lay a broader foundation for it.

But if the prerequisites of the zoologists are to be numerous their acquisition will be easy. Even now scores of universities put the services of the best naturalists at the disposal of students and offer free tuition and living to come and study with them. Librarians, great museums, great teachers

are made available to him who would work and has the requisite capacity.

All these advantages will, however, count for nothing if zoological research does not attract the best men, and if the best men be not accorded time and means for research. Our best students slip from our grasp to go into other professions or into commerce because we can offer them no outlook but teaching, administration, and a salary regulated by the law of supply and demand. We must urge without ceasing upon college trustees and corporations the necessity of freedom for research and liberal salaries if America is to contribute her share to the advance of zoology in the twentieth century.

CHAS. B. DAVENPORT.
UNIVERSITY OF CHICAGO.

SCIENTIFIC BOOKS.

Leçons de physiologie expérimentale. By M. RAPHAEL DUBOIS, professor in the University of Lyons, with the collaboration of M. EDMOND COUVREUR. Paris, Georges Carré et C. Naud. Pp. vi + 380.

These lessons in experimental physiology constitute a course of demonstrations, or lectures illustrated by demonstrations, given successfully by Professor Dubois and his pupil and collaborator, M. Couvreur, to the students in physiology of the faculty of sciences of the University of Lyons. As the authors state in the preface, they are now published with the view "of relieving the students attending the demonstrations from the necessity of taking notes, so that they may be able to devote to what they see the greatest amount of attention possible." In addition to viewing the demonstrations, the students are expected to repeat for themselves, under the direction of a master, all the classical experiments. For those who do not possess the advantage of expert supervision it is intended that the exercises described shall serve as a guide by the aid of which they may acquire a practical knowledge of physiology.

While it is encouraging to learn that something is being done to improve the teaching of practical physiology in the countries of continental Europe, where hitherto it has in general scarcely entered as a factor of any importance into the education of the student of science and particularly of medicine, we doubt whether there is a single teacher of experience in America or England who would bestow an unqualified approval upon the method adopted in this book. At the same time we can most heartily congratulate the young gentlemen (and ladies, if such there be,) of Lyons whom it releases from the bondage of the note-book and the pencil, and whose eyes and fingers (*facile princeps* in the armamentarium of physiology) it sets free for the practical study of this fascinating science.

Two well-established methods of imparting a practical knowledge of the subject are in vogue among us in schools of good standing; demonstrations by a teacher to small classes of students and practical exercises performed by the students themselves. Each of these methods has its uses, although for most purposes, and wherever the number of students is not unmanageably large, the second is by far the most satisfactory. The French lesson in experimental physiology, as typified in the Lyons course, is neither a demonstration pure and simple nor an exercise calculated to guide the student in individual practical work. It is rather a lecture on some portion of physiology, with a certain amount of actual demonstration or of talk about instruments and methods 'shoved into the belly of it.' Not full enough for systematic lectures, not precise enough in the practical directions, nor arranged with sufficient simplicity and order to be of much use as a laboratory guide, such hybrid disquisitions are neither likely, we fear, to thoroughly instruct the learner in the facts of the science nor to introduce him to a real knowledge of the methods by which the facts have been ascertained.

But when this has been said, criticism has exhausted its quiver. Faulty as is the plan of these lessons for the purposes of the elementary student, they are capable of being used with much advantage by teachers of practical physiology whom they will supply, in a somewhat

smaller compass and at a much smaller expense, with the kind of information contained in the classical 'Methodik' of Cyon, now, we believe, out of print. The advanced student also, who is able to pick and choose and piece together the information suited for his purpose, may derive considerable benefit by using the book as a supplement to other less copious but more systematically arranged manuals of practical instruction.

Beginning with the principles and technical details of the most common graphic methods of recording, the authors describe in succession the methods of fixation and anæsthetization of the animals employed; the precautions necessary for aseptic operations; the general properties of nerves and nerve centers, including the various kinds of excitation, reflex action and the effects of lesions of the brain and bulb; the general properties of muscles, illustrated by the usual myographic experiments; the mechanical, nervous and chemical phenomena of respiration in mammals, birds, reptiles and other animal groups; the mechanical and nervous phenomena of the circulation; the chemistry of the blood, lymph, the digestive juices and urine. The last lesson is devoted to animal heat. The least successful part of the book is that occupied with the chemistry of the secretions, a subject already well treated from the practical standpoint in numerous works suitable for students. The descriptions of apparatus are clear and sufficiently full, and the illustrations are well executed. In this age of blatant 'patriotism' it would seem futile to quarrel with the almost exclusive selection of French instruments and the almost exclusive citation of French authorities. In any case, if the authors have erred in this respect, their fault will be readily condoned in view of the charming naïveté of their explanation.

In matters of detail it is, of course, always easy for the captious critic to pick holes in any book. The slips and blunders in this, apart from what we think the initial vice of its plan, are neither numerous nor serious, and some of them have been corrected in a table of errata.

In the description of the action of strychnine (p. 163) the student might easily suppose, from the context that in an animal poisoned with this drug a single direct excitation of a muscle or nerve 'produces not a single contraction but a series of contractions more or less fused.' This is true, of course, only of a reflex excitation.

The statement (on p. 196), that "after double section of the pneumogastric death always takes place as a direct or indirect consequence of asphyxia (phénomènes asphyxiques) more or less rapid," is misleading.

On p. 231, the so-called 'total velocity of the circulation,' for which a better term is the mean circulation time, is not accurately defined. The only method of measuring it described is the antiquated one of Hering.

On p. 249, the automaticity of the heart-beat is attributed to the ganglia without qualification and without any indication that the majority of physiologists who, in recent times, have busied themselves with researches on this subject have come to the opposite conclusion.

We are entirely unaware of the existence of evidence sufficiently clear to justify the conclusions so boldly drawn from Stannius' experiment on p. 251, 'that the ganglia of Bidder constitute an insufficient excito-motor center, the ganglion of Remak a sufficient excito-motor center, and the ganglia of Ludwig (in the auricular septum) an excito inhibitory center whose tonus is by itself insufficient to counterbalance the excito-motor action of Remak's ganglion.'

On p. 267 it is stated that crystallized hæmoglobin (*i. e.*, reduced hæmoglobin) is unknown. Several competent authorities have described such crystals.

On p. 271, the band of reduced hæmoglobin is, for the English reader, rather comically disguised under the appellation, 'bande de Stockes,' meaning, of course, the 'band of Stokes.'

While the general rules laid down for operations on mammals and for the use of anæsthetics will, as a whole, commend themselves to all physiologists who have had much experience in the use of warm-blooded animals for teaching purposes, we must take exception to the advice that "in all operations, whether the animal is destined to be sacrified at the end of the experiment or not, the vivisector should

apply as vigorously as the surgeon the rules of antisepsis and asepsis.'' We are convinced that while, in an experimental course carried out by students, it is perfectly feasible and of great utility to insist upon rigid antiseptic precautions in such experiments as require it, they not only introduce an unnecessary complication in cases in which the animal is to be sacrificed, but often interfere seriously with, and always distract the attention of the student from the real object of the observation. Further, most of the work on mammals which can and ought to be performed by students is of such a nature that a strict adherence to antiseptic technique throughout the whole experiment is practically impossible. If the argument that "it is a bad discipline to have two styles of operation, since certain details of the antiseptic method will be fatally neglected when one wishes in exceptional cases to apply it,'' be a sound one, we ought seriously to enquire whether the reckless custom of wearing one sort of dress in summer and another in winter is not very likely to result in a fatal confusion of times and seasons, muslins and mackintoshes, shirt-waists and sealskin coats, and to lead to such awful inversions as ducks in December and ulsters in July, or whether any man who respects his stomach and has a conscientious regard for the interests of his insurance company, can afford to permit his cook to dabble at the same time in the cumulative mysteries of roast and boiled.

G. N. I. S.

The Home Life of Wild Birds. A New Method of the Study and Photography of Birds. By Francis Hobart Herrick. New York and London, G. P. Putnam's Sons. 1901. Pp. xiii + 148.

In 'The Home Life of Wild Birds,' Francis Hobart Herrick has given us a most valuable treatise and one which is sure to be of the greatest assistance to those who are following the perplexing pastime of bird photography. The author states the truth when he says that animals should be studied as animals and not as if they were human beings. If some others had shared this commendable belief, an enormous amount of trash would be absent from the book shelves and consequently seekers of truth would be saved a corresponding amount of annoyance. We have no objection to well-written fairy tales, fables, or stories of personified animals, but when an author states or implies that his human thinking and acting animals are truthfully portrayed, and the alleged facts are taken from nature, then we consider he should be most severely criticised.

Taking advantage of that force which for convenience we term parental instinct, Mr. Herrick overcomes the chief difficulty that besets the bird photographer. The method is to remove the nest from its surroundings, whether it be in the tall tree, deep wood, swamp or impenetrable brier patch, and set it up in a good light, so that the branch or other support of the nest will occupy the same relative position as in the old site. It was found that the parent birds soon got used to the new surroundings and attended the young as if nothing unusual had happened. By the aid of a green tent which concealed the operator and outfit, and when in use was open only at a point in line with the lens, the affairs of the little family could be observed with perfect ease at a distance of only a few feet. In this manner the author spent what must have been many happy days in observing the interesting movements that were taking place in and about the nests of the robin, cedarbird, kingbird, chestnut-sided warbler, bluebird, brown thrasher, red-eyed vireo, nighthawk and many other species.

The 137 pages which detail these experiments are full of valuable facts and suggestions and will surely be welcomed by those who care to learn the mysteries of bird life. The numerous photographs which enliven the book, with the exception of a few distorted on account of the nearness of the object, are admirable, and in connection with the text undoubtedly will stimulate many to seek a fascinating recreation so well described and illustrated in this volume.

A. K. F.

Washington, D. C.

DISCUSSION AND CORRESPONDENCE.

THE COAST PRAIRIE OF TEXAS.

This physiographic feature, which extends for a distance of nearly four hundred miles, from

western Louisiana through Texas into Mexico, is one of the newest made and least understood of our American geographic provinces.

In topographic aspect it is apparently an almost level plain sloping at the rate of about one foot to the mile seaward, but within its area there are slight irregularities or undulations, hitherto unnoticed or at least not described, which are now attracting great attention, owing to their supposed relation to the occurrence beneath them of oil.

The Louisiana extension of the prairie is generally acknowledged to be a subsiding land as attested by actual bench marks, by the drowned character of the bayous and by the cycles of cypress growth on the swamps. I know of no actual previous observations bearing upon the isostasy of the Texas portion of the prairie, but McGee in a recent article in the *National Geographic Magazine* assumed that it was also subsiding.

I have just made some observations, however, which lead me to believe that west of the Trinity river, at least as far south as the mouth of the Colorado—beyond which we know nothing—the plain is rising.

Between the Trinity and the Colorado all the streams have new-cut channels, characteristic of rising land, while the Brazos is actually cutting down through its own alluvium at sea level and for many miles above its mouth. Not only is the coast prairie now undergoing differential movement—subsiding in one part and rising in another—but there is strong evidence that it is being wrinkled and folded, the strata so affected being so recent in age that they cannot be assigned to any other period of time than Pleistocene or recent. These folds are so slight that they could never have been detected had it not been for the discovery of oil on Spindletop Hill, four miles south of Beaumont, by Captain A. F. Lucas, in January last.

When this gentleman endeavored to point out to me this hill, my trained topographic eye could hardly detect it, for it rises by a gradual slope only ten feet above the sea of prairie plain which surrounds it. I was still more incredulous when Captain Lucas insisted that this mound, only two hundred acres in extent, was a dome, and that it had been uplifted by the pressure of gas from the great pool of oil now proved to be coincident in extent beneath it. Captain Lucas said that I should be convinced of the uplift if I could see Damon's Mound in Brazoria County. I have just returned from Damon and a second look at Spindletop, and am convinced that if these hills are not recent quaquaversal uplifts no other hypothesis will explain their existence.

Damon's Mound is an elliptical oval hill a mile or more in greatest diameter. It rises ninety feet above the surrounding level plain. Its profile is everywhere convex instead of concave, and it is not a hill of erosion or of volcanic material. Furthermore, a bed of limestone follows the contour of its surface, showing deformation. The ascent of the plain will not carry the latter to the height of this mound for one hundred miles interiorward. The oil men have insisted on this structure and are spending $200,000 upon Damon's Mound alone, merely upon their belief that its structure is anticlinal. Not only this, but they have seized upon every hill of this character on the coast prairie of western Louisiana and Texas, and are sinking at least 100 wells at an expense of $10,000 a piece to demonstrate their theory.

Concerning the stratigraphy of the coastal plain, it can only be said that at Galveston it is composed of at least 3,000 feet of unconsolidated land, derived sands and clays, with occasional lignite logs and estuarine shells. All this is later than the Eocene Tertiary—the last datum point we have in the Tertiary and Pleistocene stratigraphy of Texas. Of this thickness Harris has shown 2,000 feet to be post Tertiary or not proved as old as Tertiary. Fossils from the Beaumont wells, depth 1,030 feet, have been assigned to the 'Neocene,' but as 'Neocene' means nothing—being merely a word to conceal our ignorance of all the later Tertiary strata of the United States—the position of the oil is still uncertain. It is my opinion that the oil is in strata which may as well be called Pleistocene or recent. They are certainly later than any proved Tertiary strata.

One thing is certain. This oil occurs in underground pools, and another thing is probable, that these pools underlie dome-shaped anti-

clines in the new-made recent coast prairies. Furthermore, these uplifts are most probably due to isostatic movements rather than to accumulations of gas.

Another interesting fact which is developing is that these oils are not associated with extensive beds of either plant or animal remains, but at one place, Saratoga, where they outcrop, they apparently originate in ferruginous sands, and this occurrence is strikingly suggestive of Mendeleef's theory that petroleum is formed by the action of warm waters on carbide of iron at considerable depths. But conclusions on this subject are as yet premature.

ROBERT T. HILL.

DISCORD AND BEATS.

TO THE EDITOR OF SCIENCE: In a review of books on physics in a recent issue of SCIENCE, I find on page 259 the remark that the author "has defined 'discord' more sharply than the facts warrant, by failure to recognize Mayer's law, which expresses the duration of the residual auditory sensation as a function of vibration frequency, the equation being expressible in a curve which Professor Mayer published in 1894 (*Am. Jour. Sci.*, Jan., 1894)." That authors of text-books of physics discuss *psychological* problems may be very well; for it is certainly better for the student to learn some psychological theories in the physical laboratory than to learn them not at all. But, unfortunately, it is rare to find a physicist who is sufficiently familiar with the psychological literature. Permit me to make these two statements: (1) That a 'discord' cannot be defined by 'beats,' the psychologists have some time since agreed upon. The physicists—on the authority of Helmholtz, whose 'Tonempfindungen' appeared 40 years ago—still make use of this definition. (2) Mayer's curve, as recent experiments (*Zeitschrift f. Psychol. u. Physiol. d. Sinnesorgane*, 20: 408–424; reviewed in the *Psychological Review*, 7: 88–90, 1900) prove, does not express the dependency of the duration of an after-sensation on the frequency of vibration. The duration of the after-sensation does not seem to depend upon the pitch at all.

MAX MEYER.

UNIVERSITY OF MISSOURI.

THE INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.

TO THE EDITOR OF SCIENCE: Can nothing be done even at this stage to secure a better system of classification for the international catalogue of scientific literature now under process of preparation under the general supervision of the Royal Society in London? In library management this country is, as probably every one is aware, in advance of most, if not all, countries, and the result of this is that the practical application of the science of classification to the cataloguing of books and articles has been carried farther in this country than elsewhere. Published systems of classification here are more complete, there is a larger literature on the subject, and a greater number of libraries have been catalogued on a classified system. I do not think anybody familiar with classification and its practical application will hesitate in condemning the classification which has been adopted by the Royal Society. In botany, it is ridiculously incomplete. It is impossible, as I know from experience, to classify material on this subject, in the shape of papers, without a system which is at least carried down to families; and in many cases one extended to genera is wise.

The classification in geology is equally inadequate and makes insufficient provision for the great extension which has taken place in physiographic geology in the last ten years.

If any one wishes to see what can be done in the line of careful classification for geological purposes, M. Mourlon's 'Classified Index of Geological Papers' on the Dewey Decimal System will offer a striking contrast to that presented by the meager array of classification in the Royal Society. Mnemonic aids are altogether omitted in this classification, no common system of number being used for common types of classification in different subjects. In the biological field, no effort has been made to follow a similar arrangement of homologous subjects.

In fact, I think, I speak within bounds in saying that no one versed in this subject can examine this classification without feeling that it is prepared by some one who has neglected to study what has already been done in this field.

There are two subjects which every one appears to think can be done by nature. One is editing a newspaper and the other is classifying. Any one who has had any experience in either will feel differently.

TALCOTT WILLIAMS.

SHORTER ARTICLES.

NOTES ON THE LIFE HISTORY OF ANOPHELES PUNCTIPENNIS AND ON THE EGG-LAYING OF CULEX PIPIENS.

SOME time during the latter part of May, 1901, a ditch about four feet in depth was dug for the water main to the new textile building on the campus. The ditch was dug in sections, one of which ran down a considerable slope just at the end of the photographic building. This section of the ditch soon became partly full of rain water. At the lower end the water was two and a half feet deep, but the water did not extend more than a third of the length of the ditch up the slope. At the upper and shallower end of the body of water, it soon became covered with a thin green slime, which upon examination proved to be wholly of *Protococcus*. In this shallow, slimy water on June 4 the writer discovered an abundance of larvæ of *Anopheles punctipennis*. They were recognized at a glance as larvæ of *Anopheles* from Dr. Howard's excellent drawings and descriptions of the larvæ of *Anopheles maculipennis*. Glass jars were immediately called into requisition, and many larvæ were carried to the laboratory, from a study of which the following notes were made. It might be of interest to say just here that there was also an abundance of larvæ of *Culex pipiens* in the same water in company with *Anopheles*.

Eggs.—It was with some surprise and a good deal of pleasure that a number of eggs were found on the surface of the water in the jars. Like *maculipennis*, they are laid at random on the water, but naturally run together and cohere in loose irregular groups or strings of from three to a score or more. Some were found floating on their sides, but the greater number seemed to be floating with the convex side, or 'back,' up and the concave side down. They differ somewhat from the eggs of *maculipennis* in shape. These eggs resemble an Indian canoe in shape, hence a cross section would be more or less triangular in outline. Seen from the side they are strongly convex above and concave below. One end is larger and blunter, while the other, as seen from the side, curves strongly downward, is smaller and more pointed. Above and on the sides the eggs are marked with a reticulate hexagonal sculpturing similar to *maculipennis*. Below, on the concave side is a dark wide line or band, extending nearly the length of the egg. It widens at each end into a club-like expansion. The writer could not be sure whether this was simply a band or a groove. Near the blunt end of the egg a transparent line runs from each side of the dark band obliquely down the sides of the egg. When the egg bursts, it breaks along these lines. At each end of the band are several dark, circular spots. The eggs varied from .45 mm. to .47 mm. in length. They hatched in 24 to 48 hours after being brought in, but no record was obtained as to the actual time of hatching after being laid, as none of the females laid eggs in captivity. It is probably safe to say, however, that they accord in this particular very closely with *maculipennis*.

Larvæ.—When first hatched the larvæ present a mottled appearance, owing to alternate dark and light transverse markings on the body. This appearance certainly suggests the spotted wings of the adult, although there perhaps can be no reason for thinking that the one in any way foreshadows the other. The larvæ retain this appearance up to the last molt, although it seems to grow less distinct with age. They lie in a nearly horizontal position just beneath the surface film of water, and when only slightly disturbed wriggle in a horizontal direction across the water instead of downward as *Culex*. When violently disturbed they wriggle downward. The more mature larvæ are more inclined to wriggle downward than the young larvæ, when disturbed. The feeding habits are almost identical with those of *maculipennis*, so fully described by Dr. Howard. The same rotary motion of the head with the under side uppermost in feeding was characteristic. There were no such differences between the larvæ of *punctipennis* and *maculipennis* as there were between the eggs of the

two species. Perhaps the mottled, or more properly the streaked, appearance of the larvæ of *punctipennis* is a distinguishing feature. Dr. Howard, we believe, mentions nothing of the kind in regard to *maculipennis*.

The duration of the larval stage, under normal conditions with plenty of food, varied from twelve to fourteen days.

On June 5 three larvæ were placed in a jar containing very little food. What food there was lay among some sand at the bottom. Two of them were very young, while the third could not have been more than half grown. These larvæ remained there until June 29, when the two younger died. These two did not go to the bottom after food and probably starved. The third and more mature one did go to the bottom after food and remained alive until July 3, when it was transferred to water containing an abundance of food. In a few days it transformed to a pupa. In this case the larval stage was over a month and could doubtless have been prolonged.

Pupæ.—The pupæ of *Anopheles* are not strikingly different from those of *Culex pipiens* to the unaided eye. A close observer, however, can learn to distinguish the two with the eye by the difference in length of the respiratory siphons. Those of *Anopheles* are much shorter. Under the microscope they are also seen to be of quite a different shape from those of *Culex*. The thorax and body of *A. punctipennis* differ quite markedly in shape from those of *C. pipiens*, when seen from above. Like the larvæ, the pupæ tend to wriggle in a horizontal direction when disturbed. They are not as active as those of *C. pipiens*, which fact is brought out very forcibly when one attempts to make a camera lucida drawing of the living pupæ of both in their natural position in the water.

The pupal stage of both males and females lasted with great regularity just about two days. At least it could not have varied more than a few hours from this, as the adults were found in every case on the second morning subsequent to the morning on which the pupæ were found.

Egg-laying of Culex Pipiens.—On July 17, in the back yard of a hotel at Magnolia, Mississippi, the writer found a pig trough five feet long, containing water to the depth of about six inches. On the surface of this water by actual count there were 257 masses of eggs of *C. pipiens*. Since there were less than five square feet of surface, one can imagine the density of egg population. It was noticed that about a dozen of the egg masses were white, or yellowish white, in appearance. This led to a more careful examination, which resulted in the discovery of a female about to finish laying a batch of eggs. Time, 6 a. m. She was so busily engaged that we could watch her with a hand lens. She rested on the surface with the abdomen at a slight angle, because the caudal end was nearly touching the surface. The mosquito stood at one end of the mass, with her head away from it. As the eggs were deposited the mass was gradually pushed away from her. The end of the abdomen was slowly carried from side to side, so that the eggs might be placed across the end and the whole mass filled out and completed as she progressed. The process may be compared with the action of the hand as a bobbin is wound with thread. The eggs always came forth with the small end first. This end, since the abdomen was held closely to the mass, would strike the other eggs and appear to be slipped along the perpendicular sides of the others, and thus be brought to an upright position. However, the tip of the abdomen was curled slightly upward, so that the egg was directed upward and very likely would have been deposited in an upright position in any case. It would have been interesting to have seen the first egg deposited. There was an appreciable interval between the deposition of each egg, perhaps two seconds, although we did not time it.

GLENN W. HERRICK.
AGRICULTURAL COLLEGE, MISSISSIPPI.

RECENT ZOO-PALEONTOLOGY.

A MARSUPIAL EVOLUTION.

IN the April *Naturalist* * is an important paper by Mr. B. Arthur Bensley upon the origin of the Australian Marsupialia. The evolution of the Marsupials is compared with that of the Pla-

* 'A Theory of the Origin and Evolution of the Australian Marsupialia,' *The American Naturalist*, Vol. XXXV., No. 492, pp. 245-269, April, 1901.

centals after the later Cretaceous, and the conclusion is reached that since the Placentals have radiated from a Creodont prototype beginning in the later Cretaceous period, it is quite possible that the Marsupials have during the same time radiated from a *Didelphys* prototype ; there is a striking general resemblance between the early Creodonts and the opossum which tends to support this theory. It is practically the working out of a hint by Huxley in 1880, and of a very suggestive paper by Dollo upon the arboreal ancestry of the Marsupials. The idea of *Didelphys* origin, however, is original with Mr. Bensley, and the detailed comparison of the evolution of the teeth of Marsupials with that of Placentals promises to give most important and interesting results. Mr. Bensley is enjoying the extensive collections of the British Museum.

GEOLOGY OF THE JOHN DAY BASIN.*

As a result of the explorations by the University of California, John C. Merriam contributes a valuable paper upon the geology of this important region in Oregon, as preliminary to the revision of the vertebrate fauna. Although this region was first reported in 1861 and explored by Condon, Marsh, Cope, Scott, Sternberg and Wortman, this is the first exact description of its geology, and is therefore most welcome and important. The author divides the beds into the Lower (250–300 feet), which is reported to contain *Oreodon;* Middle (500–1,000 feet), chiefly distinguished by *Diceratherium;* and Upper, which contained *Paracotylops*. The exact correlation of these beds with those of the Oligocene White River awaits the precise comparison and study of the faunæ. The mode of deposition has generally been considered entirely lacustrine, as the series are everywhere uniformly stratified and bedded, on the other hand, the author presents strong reasons for an æolian origin for the finer portions of these beds. In fact the problem is precisely similar to that which is now being discussed for the finer beds of the White River formation.

* 'A Contribution to the Geology of the John Day Basin,' *Bulletin*, Dept. of Geology, Univ. of California, Vol. II., No. 9, pp. 269-314, April, 1901.

DISCOVERIES OF PLESIOSAURUS AND OF PORTHEUS.

During the past season Mr. Charles H. Sternberg, well known for his years of explorations in the Kansas Chalk, made two discoveries of exceptional importance. The first is of a new type of Plesiosaur, the skeleton of which is preserved in an exceptional manner ; this has been purchased by the University of Kansas and will be described by Professor Williston as part of his general studies upon Plesiosaurs. The second is a remarkable skeleton of *Portheus molossus*, of the suborder Acanthopteri, family Ichthyodectidæ—the characteristic predaceous fish of the Niobrara. The specimen is sixteen feet in length and is in an exceptional state of preservation. It has been purchased by the American Museum of Natural History, and will be mounted facing the great specimen of *Tylosaurus* from the Kansas Chalk which has already been described in this Journal.

H. F. O.

BOTANICAL NOTES.

SHORT NOTES ON RECENT BOOKS.

Among botanical books which are likely to attract attention is Dr. Wettstein's 'Handbuch der Systematischen Botanik' of which Part 1 (including pages 1 to 202) has been brought out by the Leipzig publisher Franz Deuticke. Resembling Warming's 'Haandbog i den Systematiske Botanik' and Schumann's 'Lehrbuch der Systematischen Botanik,' it promises to be much fuller and more helpful than either, and like them is to be a general survey of the structure and classification of the Vegetable Kingdom. The attempt is made to treat the subject from the phylogenetic standpoint, and whatever of success is attained in the work is largely due to this fact. In the part now issued forty-four pages are given to a general discussion of the principles involved, followed by the special discussion of representatives of the seven phyla recognized by the author, viz.: Myxophyta (including the single class *Myxomycetes*), Schizophyta (including the classes *Schizophyceae* and *Schizomycetes*), Zygophyta (including the classes *Peridineae*, *Bacillarieae* and *Conjugatae*), Euthallophyta (including the classes *Chlorophyceae* and *Fungi*, the latter in-

cluding the lichens), Phaeophyta, the brown algae, Rhodophyta, the red algae, and Cormophyta (including liverworts, mosses, ferns and their allies, and the seed-bearing plants). The work is admirably illustrated.

The appearance of the first half of the second volume of the new edition of Pfeffer's 'Pflanzenphysiologie' (Engelmann, Leipzig) is gratifying to botanists who have been using the first volume. This part covers 353 pages, indicating that Volume II. will be considerably larger than Volume I. The present half-volume includes ten chapters, as follows: (1) Growth Movements, (2) Mechanics of Growth, (3) Growth and Cell-increase, (4) Elasticity and Cohesion, (5) Tissue Tensions, (6) Influence of Environment on Growth-activity, (7) Cause of Specific Form, (8) Variation and Heredity, (9) Rhythm, (10) Resistance to extreme Influences. A hasty glance through these chapters indicates that the work maintains the high standard of the preceding volume. The second part of Volume II. is in course of preparation, and will complete the work.

Of Engler's 'Pflanzenreich' (Engelmann, Leipzig) four parts have already appeared, dealing with the families *Musaceae* (by K. Schumann), *Typhaceae* and *Sparganiaceae* (by P. Graebner), *Pandanaceae* (by O. Warburg), and *Monimiaceae* (by Janet Perkins and Ernst Gilg). The illustrations continue to be more than unusually helpful, being clear, well drawn, and judiciously selected. In the part devoted to *Pandanaceae* there are, in addition to the ordinary illustrations, four full-page 'half-tone' plates from photographs showing the gross appearance of different arboreous species with their natural surroundings.

Thomas Howell's 'Flora of Northwest America' (Howell, Portland, Or.), has reached Fascicle 4 which includes *Liguliflorae* to *Boraginaceae* (pages 387 to 474). As the author follows the Benthamian sequence it is easy to estimate by comparison with Gray's 'Manual' that the work is not more than one-half completed. The work, although marred by typographical errors (incidental to unprofessional printing) and an 'inky' page now and then, will be a very important help to the northwestern botanists.

The last-named work reminds us of a local northwestern flora, 'The Flora of the Palouse Region,' by Charles V. Piper and R. Kent Beattie (Agricultural College, Pullman, Wash.), which appeared in May of the present year. The area covered is 70 kilometers in diameter with the town of Pullman, Wash., as a center, and includes about 24 townships in eastern Washington and 11 in western Idaho. In this region the authors describe 14 Pteridophytes, 9 Gymnosperms, 114 Monocotyledons and 526 Dicotyledons. The work of compilation appears to have been well done, and it is a pleasure to observe an attempt at a somewhat modernized terminology, and the use of metric measurements throughout. Engler and Prantl's System has been followed, and in nomenclature 'the so-called Kew and Berlin rules.' It must prove very helpful to students of northwestern Idaho and eastern Washington far outside of the limits covered.

The handy little book, 'Grasses,' by Dr. H. Marshall Ward, of Cambridge University (University Press, London), shows what may be done by a competent botanist in the way of making a difficult subject somewhat plain and not too technical. In less than two hundred small octavo pages the author gives a great deal of information, valuable not only to the student of grasses, but also to the practical man whose business it is to grow grasses for forage. There are chapters on the vegetative organs, anatomy, flowers and 'seeds' of grasses, followed in each case by a classification based on these characters alone. The book must be very useful in England and it suggests the need of a similar work for the United States.

POPULARIZING THE STUDY OF FERNS.

WHATEVER tends to increase the popular interest in plants is directly contributory to the advancement of science. Every book and every organization which stimulates an admiration and consideration of plants is to be encouraged by scientific men. Such a book is Mabel Osgood Wright's 'Flowers and Ferns in their Haunts' (Macmillan, New York), with its charming text, artistic cuts, and wonderfully accurate 'half-tone' reproductions of well-taken, well-selected, gray-mounted photographs of landscapes, where plants are shown in all their

glory. A chapter on 'The Fantasies of Ferns' is unequaled anywhere in fern literature. Not only is the text suited to the person whose mind 'is of the kindergarten order, that needs nice interesting object lessons,' but it will afford real pleasure and some instruction to the professional pteridologist, unless he has lost all sentiment, and love of the beautiful. It will prove a strong corrective for the mania which uproots every pretty, green thing. After reading it none but a confirmed vandal would wantonly disturb a colony of these beautiful plants.

Mrs. Wright's book may easily prepare the amateur for a more particular study of ferns, as suggested in Willard N. Clute's 'Our Ferns in their Haunts' (Frederick A. Stokes Co., New York). This is in fact a popular manual of the ferns of North America north of the Gulf States and east of the Rocky Mountains, and by the aid of an easy non-technical text, good cuts, and many 'half-tone' and colored plates, the subject is made so plain that no one need be without some knowledge of the ferns. It should find a place in the library of every amateur botanist, and it will do no harm to the professional botanist, who may well give it room on his shelves with other helpful books.

Why should not such books as these encourage those organizations which have for their object the cultivation of a love of Nature, and the protection of the native species? The Linnaean Fern Chapter of the Agassiz Association, which has recently issued its Eighth Annual Report (Miss Margaret Slossen, Secretary, Andover, Mass.) is such an organization of mostly amateur students of ferns. What a help such a society may become to the thousands of people who, away from herbaria and museums, desire to keep in touch with the work of others with like tastes. What an inspiration must come from membership in an organization whose members are scattered over the territory from Maine to California, and Canada to Florida and Texas, with one in England and another in far-away New Zealand.

A word may be said here in praise of a new society in Boston and its suburbs, named the 'Society for the Protection of Native Plants.' Its object is 'to check the wholesale destruction to which many of our native plants are exposed.' Every botanist will wish this society the greatest success. Its secretary is Miss Maria E. Carter, Curator of the Herbarium of the Boston Society of Natural History. The urgent need of such a society is apparent not only in the densely populated Eastern States, but fully as much in the western summer resorts, where the hand of the vandal has already exterminated some species.

CHARLES E. BESSEY.

UNIVERSITY OF NEBRASKA.

THE PRESERVATION OF COLORADO CLIFF DWELLINGS.

THE Colorado Cliff Dwellings Association is endeavoring without aid from the legislature to preserve the ruins which lie on the Mesa Verde, a tableland twenty miles long by eight miles wide, in the southwest corner of Colorado. There are from three hundred to four hundred cliff dwellings including the noted 'Cliff Palace' on this mesa. These are all in the Ute Indian reservation and consequently the state or national government can not control the ruins. A ten years' lease has been made by the Association direct with the Ute Chiefs, by means of which control is had of the Mesa. The Secretary of the Interior having ratified the lease, the Association is now in charge of the ruins, and will open a toll road to them. The money received as toll will, however, be only part of the sum paid to the Indians as rent. The ruins will be kept from weathering and from the depredations of 'relic hunters.'

HARLAN I. SMITH.

PRESENTATION BEFORE THE FACULTY OF CANDIDATES FOR THE DOCTORATE AT THE UNIVERSITY OF PENNSYLVANIA.

THE University of Pennsylvania inaugurated this year what seems to be in many respects an excellent method of recommending candidates for the degree of Doctor of Philosophy. The usual method, borrowed from the German universities, of examining candidates before the faculty or letting them defend their theses before the faculty is not altogether suited to existing conditions. In Germany it is chiefly a form and appears to be falling into disuse. The

plan is scarcely fair to the candidate if the conferring of the degree depends on the result of a public examination; it is scarcely fair to the faculty if it is a mere formality, and, as a matter of fact, members of the faculty often do not attend. The plan adopted by the University of Pennsylvania is to let the candidate pass a written examination and then bring him before the faculty, where he is presented by the professor under whom he has taken his major subject. The presentor reads a sketch of the candidate's academic life and an outline of the scope and contents of his thesis, after which any member of the faculty may make enquiries of the candidate or the presentor. As an example of the way in which the candidates are presented and as the biographies are themselves of interest, we reproduce the credentials of the first candidate presented in each of the sciences:

Professor Smith, Presentor.

Gilbert Hillhouse Boggs was born at Memphis, Tenn., October 2, 1875. He received his early education in the public schools of Athens, Ga., and entered the University of Georgia as a freshman in 1892, graduating with the degree of Bachelor of Science in 1896. He entered the Department of Philosophy of the University of Pennsylvania, February 25, 1897 and remained in residence until February 10, 1898. He reentered October 5, 1898, and has remained in residence for the past three years. His major has been in inorganic chemistry, his minors in organic chemistry and analytic chemistry. He was granted a university scholarship in chemistry for the years 1897-98 and 1898-99, and was appointed to a Harrison Fellowship at Large in the same subject for the years 1899-1901. He was admitted to candidacy for the degree of Doctor of Philosophy when appointed to the Fellowship.

He has completed under the jurisdiction of Group Committee XIV. thirty-three standard lecture courses, exclusive of the laboratory work which has occupied the greater part of his time for four academic years. He has satisfactorily passed written examinations in inorganic, organic and analytical chemistry on May 28-30, 1901, with Professor Smith, Drs. Lorenz and Shinn.

Mr. Boggs has presented a thesis entitled 'I. The Separation of Vanadic Acid from Metals by means of Hydrochloric Acid Gas. II. The Occurrence of Molybdenum in the Mineral Endlichite,' of which the following is an abstract:

Vanadium is being frequently found present in traces in rocks and minerals. Its separation from allied metals is extremely difficult, and in this research the purpose has been to ascertain how completely hydrochloric acid gas will eliminate the vanadium, it being well established that from the alkali metals the vanadic acid is completely removed by this reagent. This study shows that with the exception of the alkali group of metals the new reagent is inadequate. An additional point of interest is that the metal molybdenum exists in the mineral endlichite, and that its presence there accounts for the fact that the vanadic acid of endlichite is removed by hydrochloric acid gas, probably because it exists as a vanado-molybdate of lead, a form different from that in which it is observed in vanadinite.

Mr. Boggs' thesis is now in the hands of the printer, and the required number of copies will be delivered to the Dean within a few weeks. Mr. Boggs is unanimously recommended by Group Committee XIV. to the Faculty of Philosophy for the degree of Doctor of Philosophy.

Professor Macfarlane, Presentor.

Henry Shoemaker Conard was born in Philadelphia, September 12, 1874. He received his early education at the Friends' Select School and Westtown Boarding School. He entered Haverford College as a junior in 1892, and graduated with the degree of Bachelor of Science in 1894. He was a graduate student at Haverford 1894-95, receiving the degree of Master of Arts in 1895. During the four years, 1895 to 1899, he was teacher of science in the Westtown School. He entered the Department of Philosophy, of the University of Pennsylvania, September 26, 1899, as Harrison Fellow in Biology, being thereby made a candidate for the degree of Doctor of Philosophy. He elected his major in botany, his minors in botany and zoology. He has completed in this University, under the jurisdiction of Group Committee XV., twenty standard lecture courses, besides spending practically all his spare time for two years in the laboratory, and has also received credit for his work at Haverford to the extent of four standard courses, making a total of considerably more than twenty-four. He has satisfactorily passed written examinations as follows: On May 28 and 29, 1900, in zoology; on February 7 and 11, 1901, in botany as a minor, and four further examinations in botany as a major, running from May 21 to 22, 1901.

He has presented a thesis entitled 'Water Lilies: a Monograph on the Genus *Nymphæa*.' It will be published in the next volume of the Series in Botany, issued by the University of Pennsylvania. A brief abstract of this thesis is subjoined:

Mr. Conard has described about thirty natural spe-

cies. A like revision has never appeared in English, and not in any language since 1853, during which time many new facts have been brought out. The classification differs slightly from that of previous workers, in view of recently discovered facts of hybridization. An attempt is made to arrange the types as nearly as possible in their evolutionary relationships. Twelve species, representing all the natural groups from all parts of the world, and a number of hybrids and varieties, have been studied carefully in cultivation in the Botanic Garden of the University. Others also have been studied in the collection of the Henry A. Dreer Company, at Riverton, N. J., and elsewhere. Each description takes up :

1. Diagnostic characters.
2. Literature and synonymy.
3. Minute morphological, physiological and, in some critical cases, histological descriptions of flower, leaf, stem and root, and the development from seeds and tubers.
4. Habitat.
5. Remarks, historical and critical.
6. Varieties similarly described.

The results of a number of observations on the times of daily opening and closing of the flowers are incorporated in the descriptions ; these, and the developmental histories of species are, for the most part, entirely new records. The paper is illustrated with photographs and line drawings.

Mr. Conard is unanimously recommended to the Faculty of Philosophy by Group Committee XV. for the degree of Doctor of Philosophy.

Professor Crawley, Presentor.

Burton Scott Easton was born in Hartford, Conn., December 4, 1877. He received his early education at the Hamilton School, Philadelphia, and with private tutors in Germany. He entered the University of Pennsylvania as a freshman in 1894, receiving the degree of Bachelor of Science in 1898. During the year 1898-99 he was instructor in mathematics and astronomy in the State University of Iowa, and pursued graduate work in the same institution. He entered the Department of Philosophy of the University of Pennsylvania, September 27, 1899, electing his major in mathematics, one minor in mathematics, and the other minor in astronomy. He was appointed Harrison Fellow at Large in Mathematics for the year 1900-01, and was transferred to the regular fellowship in mathematies and astronomy January 11, 1901. He has received credit for the following work : (1) For graduate work in mathematics pursued before receiving his Bachelor's degree, and not credited toward that degree, four standard courses ; (2) for graduate work in mathematics at the State University of Iowa, six courses ; (3) for graduate work in this University since 1899, sixteen courses, a total of twenty-six standard courses. He has satisfactorily passed written examinations on March 30, April 4 and May 16, 1901, in mathematics with Professor Crawley, Assistant Professors Fisher and Schwatt and Dr. Hallett ; on March 16, 1901, in astronomy with professor Doolittle and Mr. Eric Doolittle. He has presented a thesis entitled 'Substitutions and Substitution Groups.' He has deposited with the Dean a copy of this thesis and the money necessary to print it. The thesis will appear in the spring of 1902. A brief outline of its contents is as follows :

The group theory is one of the most recent developments of mathematics. It is far-reaching in its applications and is a most prolific field of research at the present day. The literature of the subject is, however, principally to be found scattered through the pages of the mathematical and scientific journals, and is therefore disjointed and fragmentary not only in form but also in the manner of its presentation. Moreover, much of importance is almost useless from the difficulty of finding it when wanted.

The primary object of the dissertation is to present the results of the most recent investigations in this subject in such a manner as to give a coherent view of what has been done. The way in which this has been accomplished by the candidate shows good mathematical judgment, and a thorough appreciation of the philosophy of recent mathematics. Only a portion of what has actually been accomplished in carrying out this work is embodied in the dissertation, which is devoted in the main to a careful consideration of transitive and intransitive groups, primitive and imprimitive groups, and the isomorphism of one group with another. The limits of *transitivity* have received special attention. A certain looseness has been found to exist in the use of some terms, notably in the expression 'permutable groups.' Mr. Easton has given precise definitions in all these cases, and the necessary modifications in the subsequent developments have been introduced.

Mr. Easton is unanimously recommended to the Faculty of Philosophy by Group Committee XI. for the degree of Doctor of Philosophy.

Professor Doolittle, Presentor.

Henry Brown Evans was born in Dayton, Ohio, July 2, 1871. He was educated in the public schools of his native town, graduating from the High School in 1889. He entered the Freshman Class of Lehigh University the same year, and received the degree of Mechanical Engineer in 1893. He was instructor in mathematics and astronomy at Lehigh, 1894–95, and has been instructor in astronomy in this University

since 1895. He entered the Department of Philosophy October 23, 1895, electing his major in astronomy, his minors in mathematics and philosophy. He was admitted to candidacy for the degree of Doctor of Philosophy October 1, 1897. He has completed twenty-seven standard courses. He has satisfactorily passed written examinations in astronomy with Professor Doolittle on May 4 and 11, 1901 ; in mathematics with Assistant Professors Fisher and Schwatt on March 7, 1901 ; in philosophy with Dr. Singer on March 25, 1901. He has presented a thesis entitled 'The Right Ascensions of One Hundred and Eighty Latitude Stars,' and has deposited with the Dean a copy of the manuscript and the money necessary to print it. The scope of this thesis may be described as follows :

The determination of the latitude of any single point of the earth's surface, by the zenith telescope method, depends ultimately on the positions of the stars observed for that purpose. The object of this thesis is the determination from all available data of definitive values of the right ascensions of one hundred and eighty stars. This material is needed for the determination of the variations of latitude at the Sayre Observatory of Lehigh University and at the Flower Observatory of the University of Pennsylvania. A definitive investigation of the right ascensions has not been undertaken before this. The necessary data were found in the star catalogues heretofore published, from 1755 to date. Altogether positions of these stars were taken from about one hundred such sources. The observed positions were then combined by the method of least squares, and the definitive values of the right ascensions of the one hundred and eighty stars in question for 1875.0 were thus determined.

Mr. Evans is unanimously recommended to the Faculty of Philosophy by Group Committee XII. for the degree of Doctor of Philosophy.

Professor Patten, Presentor.

John Paul Goode was born at High Forest, Minn., November 21, 1862. He received his early education in the public schools of Olmstead County, Minn., and in the Rochester Seminary, Rochester, Minn. He entered the University of Minnesota as a freshman in 1885, and received the degree of Bachelor of Science in 1889. From 1889 to 1898 he was professor of the natural sciences in the State Normal School, Moorhead, Minn. He spent the summer of 1894 in the Summer School of Harvard University, that of 1895 as a graduate student in geology at the University of Chicago, that of 1896 as instructor in geology in the Summer School of the University of Minnesota. During the autumn and winter quarters of the year 1897–98 he was fellow in geology at the University of Chicago, being absent on leave from his professorship. During the four summers, 1897, '98, '99 and 1900, he was instructor in physiography and meteorology at the University of Chicago. In the year 1898–99 he spent the autumn, winter and spring quarters as a graduate student of geology and economics at the University of Chicago. In 1899 he was appointed to the professorship of the physical sciences and geography in the Eastern Illinois State Normal School, Charleston, Ill., which position he still holds, having been absent on leave during the past academic year.

He entered the Department of Philosophy of the University of Pennsylvania October 1, 1900, and remained in residence until April 5, 1901. On March 8, 1901, the Executive Committee decided to consider this period of residence as satisfying the rule requiring one year of residence. Mr. Goode elected his major in economics, his minors in geology and sociology. He completed in the University of Chicago fifteen standard courses in geology, two in mineralogy, and eight in economics. In this University he has completed in economics nine standard courses, making a total of thirty-four. He has satisfactorily passed written examinations on November 16, 1900, in physiography with Assistant Professor Brown ; on March 30 and April 4, 1901, in economics with Professor Patten and Assistant Professor Seager ; on March 23, 1901, in economic geology with Assistant Professor Brown, and on April 1 and 3, 1901, in sociology with Assistant Professor Lindsay. He has presented a thesis entitled 'The Influence of Physiographic Factors upon the Occupations and the Economic Development of the United States.' He has deposited with the Dean a letter from Mr. E. M. Lehnerts, guaranteeing the publication of the thesis in the *Bulletin of the American Bureau of Geography*. The scope of the thesis may be briefly described as follows :

1. A study of the geographic location of the United States, showing its relation to other lands and the effects that this position has on its climate.

2. A sketch of the geographical development of North America, and its effects on the distribution of mineral wealth, drainage and the formation of soils.

3. A detailed study of the physiographic provinces of the United States, showing how the relief of the land facilitates or obstructs settlement and trade. With this is given a classification of harbors and many illustrations of how they are formed and improved or destroyed.

4. A study of climate, of ocean currents and of the distribution of the rainfall.

5. The influence of forests on man ; his debt to

wood as a material in the constructive arts. Future possibilities of forests when coal is gone.

6. A study of the common cereals and the conditions of soils and climate demanded by each species.

Mr. Goode is unanimously recommended to the Faculty of Philosophy by Group Committee X. for the degree of Doctor of Philosophy.

Professor Conklin, Presentor.

John Raymond Murlin was born in Auglaize County, Ohio, April 30, 1874. He received his early education in the public schools of Mercer County, Ohio, at the Ohio Normal University, and in the Preparatory Department of Ohio Wesleyan University. He entered the Ohio Wesleyan University as a freshman in March, 1894, and received the degree of Bachelor of Science in June, 1897. During his senior year he was instructor in physiology and histology, and the following year was instructor in physiology and zoology in the same institution. He entered the Department of Philosophy of this University, September 24, 1898, electing his major and one minor in zoology, and one minor in botany. In 1899 he was granted a Harrison Fellowship at Large in zoology, this appointment carrying with it candidacy for the degree of Doctor of Philosophy. He was reappointed to the same Fellowship for the current year.

He has completed in this University twenty and one-fourth standard courses, and has in addition devoted practically his entire time for three years to laboratory work, the summers of these years being spent in the Marine Biological Laboratory at Wood's Holl, Mass. The laboratory work which Mr. Murlin has done would probably be equivalent to sixty standard courses. He has satisfactorily passed written examinations in zoology on May 28 and June 2, 1900, with Professor Conklin and Dr. Moore; on May 28 and 29, 1901, with Professor Conklin and Assistant Professor Montgomery, and in botany on May 30, 1900, with Professor Macfarlane.

Mr. Murlin has presented a thesis entitled, 'The Digestive System of the Land Isopods, with special reference to the Morphology of Absorption and Secretion,' and has deposited with the Dean a copy of it, together with the money necessary to print it. Its scope may be outlined as follows:

Structural and functional changes in the intestine of two common genera of land Isopods have been followed during (1) growth; (2) the process of shedding the chitinous lining; and (3) the stages of food absorption. The intestine might be described as a cylindrical conduit, the wall made up of a single layer of cubical elements of the same size, and lined with a homogeneous but porous intima. These elements, the cells, are very large, being visible in adult specimens even to the naked eye. The minute structure of both cell-body and nucleus is seen with high powers of the microscope to be alveolar, *i. e.*, the protoplasm is composed of very small semi-fluid vesicles, between which is a homogeneous interalveolar substance and supporting fibers, running from the inner to the outer side of the cells. During growth of the animal the intestine increases in size both by multiplication (direct cell-division) and by enlargement of the cells. When the lining (chitin) is shed, the fibers on the side of the cells next the lumen disappear, and in their place is seen a fluid substance, by the hardening of which the new lining is laid down.

In the digestion of proteids, as is well known, several stages intervene between the insoluble condition in which the food enters the stomach, and the readily soluble condition which it must reach before it can be assimilated. Hitherto the food has been traced *to* the absorbing cells, and has been identified in different form in the blood of many animals after having traversed the cells. The purpose of this study was to follow the food *through* the cells. Albumose, the first soluble stage in the digestion of albuminous foods, is recognized in the cells eight hours after feeding. The food in this form traverses the interalveolar spaces, and may accumulate in the outer side of the cell from sixteen hours after feeding, onward. The course of the food through the wall of the intestine is not visibly influenced by the cell-structure except in a purely mechanical manner. Albumose is not found in the blood of the animal, which bathes the outer side of the intestinal wall; the inverse change back to albumen must therefore be effected before the food reaches the circulation. A finely granular substance comes from the nucleus and is associated with albumose in its passage through the cell; it probably acts on the albumose either to carry the digestive process farther, or to begin the inverse process (synthesis toward albumen), or both.

Carbohydrates are readily digested in the intestine, dextrose, the soluble form of starch, being found twenty-four hours after feeding. In the absorption of fats the indications are that splitting-up by ferment action into fatty acid and glycerine takes place in the lumen of the intestine, and synthesis by ferment action takes place within the cell.

The digestive secretion is first recognized in immature cells of the 'liver' in the form of (zymogen) granules. During the growth of these cells the granules increase in size, become looser in structure, more soluble in certain reagents, and more stainable. The secretion is set free into the lumen of the gland in the form of a proteid fluid by mere evacuation of the cells, or by fragmentation and dissolution of their luminal ends. Discharging cells are found from

twelve to ninety hours after feeding with proteids. The secretion is poured into the intestine, where it acts by means of its ferments on the three classes of foods : proteids, carbohydrates and fats.

Mr. Murlin is unanimously recommended by Group Committee XV. as a candidate for the degree of Doctor of Philosophy.

Professor Crawley, Presentor.

Roxana Hayward Vivian was born at Hyde Park, Mass., December 9, 1871. She received her early education in the public schools of Hyde Park, graduating from the High School in 1890. She entered the freshman class of Wellesley College the same year, receiving the degree of Bachelor of Arts in 1894. From 1895 to 1898 she taught Greek and mathematics in a preparatory school, and from 1896 to 1898 pursued graduate work in the same subjects at Wellesley college. She entered the Department of Philosophy of this University October 10, 1898, as alumnæ fellow in mathematics. This appointment carried with it candidacy for the degree of Doctor of Philosophy. She was twice reappointed to her fellowship, holding it for three successive years. She elected her major and one minor in mathematics, and the other minor in astronomy. She has completed thirty standard courses, and has satisfactorily passed written examinations in astronomy with Professor Doolittle and Mr. Eric Doolittle, February 14, 1901 ; in mathematics with Professor Crawley, Assistant Professors Fisher and Schwatt and Dr. Hallett, on April 4 and 13, and May 11, 1901. She has presented a thesis entitled 'The Poles of a Right Line with Respect to a Curve of Order n.' The thesis will be printed at once. Pending its appearance Miss Vivian has deposited with the Dean a copy of the manuscript and the money necessary to print it. The scope of the thesis may briefly be outlined as follows :

The general subject of poles and polars with respect to Higher Plane Curves has been studied by numerous mathematicians, notably by Steiner, Cremona and Clebsch. Steiner gave in *Crelle's Journal*, Vol. XLVII., a large number of theorems relating to this subject, but he omitted the proofs. They were all proved subsequently by Cremona. Cremona's method was peculiar to himself, that is, he adapted a somewhat more general theory, that of the loci of harmonic means, to the theory of poles and polars. In discussing these problems Miss Vivian uses the analytic method. The particular line of discussion which she has taken up is one which has not been treated in any detail by any former writer. She has handled the subject ably, and has arrived at some very interesting results. In one or two instances her results show that the statements of former writers must be taken with certain limitations, which do not appear to have been considered. Her principal object is to establish the ways in which the poles of a line are limited when the line has certain prescribed relations to the fundamental curve of the nth order, and to its allied curves, the Hessian and Steinerian. Under particular conditions certain points in the plane will be poles for all lines in the plane, while the other poles, called by the candidate 'free poles,' vary with the line. Many writers do not class the first as poles at all, but it seems more reasonable to class them with the other poles, since they have all the required properties of such points ; and, besides, it is more in keeping with the present tendency of thought on these subjects to do so. The subdivisions of the paper are as follows :

1. The pencil of curves of which the poles are base points.
2. The related curves.
3. Poles when the curve u-o has no singularities.
4. The inflection locus.
5. Poles when the curve u-o has double points and cusps.
6. Intersections of higher order with the Steinerian.
7. u-o with triple points and higher multiple points.

Miss Vivian is unanimously recommended to the Faculty of Philosophy by Group Committee XI. for the degree of Doctor of Philosophy.

SCIENTIFIC NOTES AND NEWS.

WE publish in this issue of SCIENCE the admirable presidential address given before the American Association, at Denver, on Tuesday, by Professor Woodward, and the vice-presidential address given by Professor Davenport before the Zoological Section, which is also a model of what such an address should be. We hope to publish next week an account of the meeting and one or two further addresses by the vice-presidents.

PROFESSOR THEODORE WM. RICHARDS, of Harvard University, has been invited to fill the newly established professorship of inorganic chemistry in the University at Göttingen. The position is entirely free from routine teaching, being confined to research work with the assistance of such advanced students as may be selected. It will be remembered that Professor J. H. van't Hoff was called from Holland to fill a similar position at the University of Berlin. The fact that Germany should invite two for-

eigners to such important positions demonstrates the broad-mindedness and freedom from prejudice which in part accounts for the high positions that its universities maintain. The creation of chairs devoted to research is also a forward movement in Germany, which it will be necessary for this country to follow. It is certainly a great compliment to the United States that Germany should seek here a professor for such a chair, more especially when we remember the very great number of chemists that are being trained in Germany. We are glad to learn that the president and fellows of Harvard College have taken action leading Professor Richards to remain in this country.

THE Veitch silver medal has been awarded to Mr. Thomas Meehan, of Philadelphia, 'for distinguished services in botany and horticulture.' Mr. Meehan is the third American on whom this medal has been conferred, the others being Professor Charles S. Sargent, of the Arnold Arboretum, and Professor Liberty H. Bailey, of Cornell University.

PRESIDENT LOUBET of France has conferred upon President W. R. Harper, of the University of Chicago, the decoration of the Legion of Honor.

MR. MARSHALL H. SAVILLE had been named Officier d'Académie by the French Government in recognition of his archeological researches in Mexico for the American Museum.

ON the recommendation of the Council of the Royal College of Physicians, England, it has been unanimously resolved "that the Baly Medal be awarded to Frederick William Pavy, M.D., F.R.S., F.R.C.P., for his researches on 'The Physiology of the Carbohydrates; their Application as Food, and Relation to Diabetes,' 1894; but more especially for his original investigations on sugar formation in the liver, which he has carried on during the last forty years, and with unabated enthusiasm during the last two years."

DR. VINCENT CZERNY, the eminent professor of surgery at the University at Heidelberg, is on his way to the United States, in order to visit our medical schools.

WE noted recently that a monument to Chevreul had been unveiled in the Court of the Museum of Natural History, Paris. We learn from French exchanges that addresses were made on the occasion by M. Edmond Perrier, director of the Museum, by M. Armand Gautier, representing the Acadamy of Sciences and the Academy of Medicine, by M. Arnaud, who in 1890 succeeded Chevreul in the chair of organic chemistry at the Museum, by M. David, director of the chemical laboratory of the Gobelin's Manufactory, and by M. Puglier-Conti, vice-president of the Paris municipal council. The marble statue is by M. Fagel, and is erected on a pedestal bearing the inscription:

CHEVREUL
MICHEL-EUGÈNE
NÉ A ANGERS LE 31 AOUT 1786
MORT A PARIS LE 7 AVRIL 1889
PROFESSEUR DE CHIMIE ORGANIQUE
1830–1889
DIRECTEUR DU MUSÉUM D'HISTOIRE NATURELLE
1863–1884

IT is proposed to erect a statue of Pasteur at Marnes, near Saint Cloud, where Pasteur spent the last years of his life. M. Duparquet, mayor of Marnes, is chairman of the executive committee.

DR. HENRY BENNER, professor of mathematics at Albion College, was drowned on August 14, in Lake Orion.

The death is announced of Dr. Domenico Stefanini, professor of bacteriology at the University of Pavia, at the age of eighty years; and of General Venukoff, a Russian geographer and geodesist living at Paris, at the age of seventy-one years.

THE Vienna Academy of Sciences announces that the prize founded by Freiherr von Baumgartner, will be awarded at the end of 1903 for a research enlarging our knowledge of the invisible radiations. The value of the prize is 2,000 crowns.

AT the meeting of the International Congress of Botanists which opened at Geneva, on August 7, it was voted to establish a Société Internationale de Botanique, and a series of laws was formulated which will be sent in print to botanists interested. It was decided to purchase the *Botanisches Centralblatt*, includ-

ing all back numbers, index and *Beihefte*, of the present publishers, Gebrueder Gotthelft, of Cassel. The journal is to be registered and a limited company formed in Holland. Shares will be sold to cover the purchase. Beginning with January, 1902, it will be published by E. J. Brill, of Leyden, with Dr. Uhlworm as editor and Dr. Kohl as assistant. Annual subscribers are to have equal rights with the stockholders in conducting the business. The Société elected Professor Karl Goebel of Munich, president, Professor F. O. Bower, of Glasgow, vice-president and Dr. J. P. Lotsy, Tjëbodas, Java, secretary. The next meeting is to be held in Vienna, three years hence. Switzerland and France were most largely represented among the delegates present. The United States were represented by Professor J. C. Arthur, Dr. D. S. Johnson, Dr. F. E. Lloyd, Mr. W. Murrill and Dr. H. von Schrenk as delegates. The delegates were very hospitably received in Geneva, and a banquet was given in their honor. After the meeting some of the delegates, under the direction of Professor Chodat, of Geneva, made an excursion among the Swiss Alps.

According to a cablegram to the daily papers the most important question of the meeting of the Zoological Congress came up on August 14, in the Committee on Nomenclature. Two propositions were presented. The French delegation proposed to make the existing nomenclature conform with the classic Latin, grammatically and etymologically. The American delegates proposed to make no changes, except in the case of obvious typographical errors. The Germans made a compromise proposition, which did not find favor. After a warm discussion the French proposition was accepted, the Swiss delegates giving the deciding vote for the proposal. The Dutch delegates and part of the German delegation voted with the Americans. The British delegates voted with France.

The French Surgical Congress will hold its fourteenth annual meeting in Paris on October 21 and following days.

We learn from the *British Medical Journal* that an Egyptian Medical Congress is to be held under the patronage of the Khedive at Cairo from December 10 to 14, 1902, under the presidency of Dr. Abbate Pacha. The honorary presidents are Dr. Ibrahim Pacha Hassan, Dr. Pinching, and Dr. Ruffer. The general secretary is Dr. Voronoff. The work of the Congress will be divided among three sections, as follows: (1) Medical Sciences, presided over by Dr. Comanos Pacha; (2) Surgical Sciences, presided over by Dr. H. Milton; and (3) Ophthalmology, presided over by Dr. Mohammed Bey Eloui. The program of the Congress will include discussions on affections especially rife in Egypt, such as bilharzia, ankylostomiasis, bilious fever, abscess of the liver, etc. Special attention will be given to questions relative to the epidemics which for some years past have regularly visited Egypt, and the prophylactic measures to be taken against them. The following papers among others have been promised: 'Alcoholism and its Increase in Egypt,' by Dr. de Becker; 'The Frequency of Hydrocele in Egypt and its Treatment,' by Dr. Colloridi; 'Myxœdema in Egypt,' by Dr. Brossard; 'Plague,' by Dr. Gotschlich; and 'Tuberculosis in Egypt,' by Drs. Ibrahim Pacha Hassan, Eïd. and Sandwith.

The twelfth annual general meeting of the Institution of Mining Engineers will be held at Glasgow on September 3–6, under the presidency of Sir W. T. Lewis, Bart.

Following the Congress on Petroleum, held in Paris in 1900, a second congress will be held in Paris in 1902. A permanent committee has been formed in Paris under the presidency of M. Ed. Lippmann, the secretary of the congress, and M. Dvorkovitz has recently established in London an institute for the scientific study of petroleum.

A meeting of the Board of Visitors of the National Bureau of Standards was called in Washington, for August 23d, for the purpose of passing on proposed sites for the laboratory of the bureau. It will be remembered that the five members of the Board of Visitors were appointed by Secretary Gage, and are as follows: Dr. H. S. Pritchett, president of the Massachusetts School of Technology; Dr. Ira Remsen, president of the Johns Hopkins University; Dr.

Elihu Thomson; Professor Edward L. Nichols, of Cornell University, and Albert L. Colby, of Pennsylvania.

ACCORDING to *Nature* the Paris correspondent of the *Chemist and Druggist* states that with a view to giving an impetus to the study of applied chemistry in Paris, it has been decided to build additional laboratories at the Conservatoire des Arts et Métiers. The initial expense is estimated at 500,000f. (20,000*l*.), and the annual upkeep at something over 3,000*l*. The laboratories will also be used for experiments in physics and mechanics.

THE German Government has sent an expedition to German East Africa for the purpose of organizing a systematic effort for the prevention of malaria. The expedition is under the command of Dr. Ollwig, Staff-Surgeon *à la suite* serving with the Imperial forces in East Africa.

A NORTH German Lloyd steamer has been chartered to leave Sydney, N. S. W., on October 11 for Kerguelen Land, conveying provisions and dogs for the German Antarctic expedition on board the steamer *Gauss*.

THE book on 'Mosquitoes' by Dr. L. O. Howard, recently reviewed in this journal by Professor Packard, is being translated into Spanish.

THE Station of the U. S. Fish Commission on the Great Lakes, with headquarters at present at Put-in-Bay, Ohio, is collecting the literature of fresh-water fauna and flora, and Professor H. S. Jennings, who has charge of the Station, will be glad to receive from authors and others publications in these subjects.

M. MAREY, the president of the International Committee on Physiological Instruments, will be glad to have sent to him at Boulevard Delessert, No. II., Paris, new physiological apparatus for presentation at the International Congress of Physiology to be held at Turin next month.

FOR the last week for which the report is at hand, the deaths from the plague in India numbered 1,125. At the same period last year there were only 200 deaths.

WE learn from *Nature* that the annual awards of prizes by the Reale Accademia dei Lincei, of Rome, are as follows: The Royal prize for chemistry has been adjudged to the late Professor Amerigo Andreocci for his researches on heterocyclic compounds and on the santonine group, and other papers. The Royal prize for philosophy and moral science has been adjudged to the late Professor Carlo Giussani. In political science and jurisprudence no award has been made, and the same is true of the Santoro prize relating to agricultural zoology. The two prizes instituted by the Minister of Public Instruction in favor of teachers in secondary schools for work in natural science have been divided, awards being given to Professors Liberto Fantappiè (Viterbo), Antonio Neviani (Rome), De Toni (Venice), and Giacomo Trabucco (Florence). Two 'Ministerial' prizes of a similar character for philosophical and social sciences are awarded to Professors Luigi Einaudi (Turin) and Aurelio Covotti (Palermo).

THE annual meeting of the Fellows of the Royal Botanic Society, according to the report in the London *Times*, was held on August 10, in the museum in the society's gardens at Regent's Park. Mr. C. Brinsley Marlay presided. The Duke of Teck was elected president, Mr. G. J. Marjoribanks treasurer, and the Marquis of Breadalbane, Earl Howe, the Earl of Aberdeen, Sir Henry Oakley, Sir J. Blundell Maple, M.P., Mr. J. Fletcher, Dr. R. C. A. Prior and Mr. W. Sowerby were reelected members of the council. The 62d annual report stated that the negotiations with the Department of Woods and Forests had been concluded and a new lease of the gardens had been granted for 31 years. The accounts showed that the year's working had resulted in a profit of £285, being nearly double that of the previous year. The number of fellows on the books was 2,124, which showed a steady increase in number, 88 new fellows having joined the society during the year. The garden's club continued to form one of the attractions of the society, 41 fellows of the society having joined the club during the year; and the past season had been a very successful one. The chairman, in moving the adoption of the report, said that the prospects of the society were decidedly better than they had been for some years past. Their lease had been renewed and a large number of their debentures —viz., £5,700—had been taken up. The so-

ciety was in a transition state. Mr. Austen Chamberlain, as representing the Treasury, had insisted that the society should open its gates to the public a certain number of days in the year; in fact the public had rights there which had to be recognized. Therefore the old character of the gardens had almost completely disappeared. The Society still retained its scientific character, however, and whatever facilities they could give to promote science, particularly botany, they would give. They had been unable to obtain a grant from the Government, and the scientific part of the gardens was, therefore, carried on with great difficulty. The subscriptions of the fellows were not sufficient to keep up the gardens as they should be kept up, and the council had to rely, therefore, in some measure upon the entertainments. Towards the end of the meeting the chairman called attention to the skill and beauty of a large number of Japanese drawings of flowers and birds, of which he had a very fine collection.

AT the last meeting of the Berlin Medical Society, held on July 25, Professor Virchow is reported by the *Lancet* to have alluded to the recently-enunciated views of Professor Koch as to the non-identity of tuberculosis in cattle with that affecting the human subject. In his sarcastic style he remarked that he was happy to find that Professor Koch's views had undergone a change and were now in accordance with his own, for he had maintained that the mere presence of the Koch bacillus was not the essential thing in tuberculosis; a tubercle was, in his opinion, a growth with a distinct anatomical structure, and he had always protested against the bacteriologists terming anything a tubercle simply because a Koch bacillus happened to be present. He said that the adherents to Koch's theory had believed his view to be rather old-fashioned, but it did not annoy him to recall to mind that he had sometimes been superciliously treated by the younger bacteriologists. Professor Virchow's ironical words produced a great impression on the meeting.

ACCORDING to the *Comptes Rendus*, as translated in the *Scientific American*, H. Becquerel has confirmed, by an unpleasant experience, the fact first noted by Walkoff and Giesel, that the rays of radium have an energetic and peculiar action on the skin. Having carried in his waistcoat pocket for several periods, equal in all to about six hours, a cardboard box enclosing a small sealed tube containing a few decigrammes of intensely active radiferous barium chloride, in ten days' time a red mark corresponding to this tube was apparent on the skin; inflammation followed, the skin peeled off and left a suppurating sore, which did not heal for a month. A second burn subsequently appeared in a place corresponding to the opposite corner of the pocket where the tube had been carried on another occasion. P. Curie has had the same experience after exposing his arm for a longer period to a less active specimen. The reddening of the skin at first apparent gradually assumed the character of a burn; after desquamation a persistent suppurating sore was left which was not healed fifty-six days after the exposure. In addition to these severe 'burns' the experimenters find that their hands, exposed to the rays in the course of their investigations, have a tendency to desquamate; the tips of the fingers which have held tubes or capsules containing very active radiferous material often become hard and painful; in one case the inflammation lasted for fifteen days and ended by the loss of the skin; and the painful sensation has not yet disappeared, after the lapse of two months.

ACCORDING to a notice in *Nature*, the annual report of the Russian Geographical Society for 1900 notes the growing activity of the young branches of the society at Vladivostok, Kiakhta, Tomsk and Orenburg—their work being not limited to pure geography, but being mainly directed to the exploration of the geology, botany, zoology and prehistoric anthropology of the respective regions. A new local museum has consequently been opened at Troitskosavsk, near Kiakhta, in addition to those of Minusinsk and Yeniseisk. The chief medal of the Geographical Society, the Constantine medal, was awarded this year to V. Obrucheff, the explorer of the Nan-shan and Mongolia, who has also explored very large portions of Transbaikalia and the Pacific littoral, and whose preliminary

reports are always of the deepest interest for both the geologist and the orographer. The Count Lütke medal was awarded to M. E. Zhdanko for his extensive geodetical and hydrographical works in the far North, the Semenoff medal to J. A. Kersnovsky for work in meteorology, and the Prjevalski medal to the Tomsk professor, V. V. Sapozhnikoff, whose explorations of the Altai highlands revealed hundreds of unknown glaciers, as well as widely-spread traces of glaciation, and threw much new light on the geography of the whole region. These researches are now embodied in a work, 'The Katuñ and its Sources' (with maps and a summary in French).

The Society of Chemical Industry held its annual meeting at Glasgow at the end of July. The secretary reported that the society was in the most prosperous condition, there being now 3,632 members. The president, Mr. J. Wilson Swan, chose as the subject of his address 'Electro-chemical Industry.' According to the abstract in the London *Times* he traced the progress of this branch of applied science from the early laboratory researches of Davy and Faraday down to the position it occupied at the present time. He gave particulars of the power at present utilized and products made in the 150 works using electricity for chemical and metallurgical purposes in Europe, and described the methods employed in the several branches of manufacture. In several instances the new methods of manufacture had already supplanted the old, while in others there was keen competition between the chemical and the electrolytic processes. Turning to the future, Mr. Swan pointed out that the united kingdom was severely handicapped as regards these new developments by her lack of water-power. In spite of this, however, many of the new electro-chemical industries could be carried on profitably with steam-power. The utilization of the waste gases of blast furnaces in large gas-engines for the generation of electrical energy would also become a realized fact, and would supply large quantities of cheap power for the industries under discussion. While, therefore, admitting that the position of the staple chemical and allied industries in England had been undermined to some extent by the rapid growth of electro-chemical industries abroad, and that protective tariffs were being employed to shut out British products, Mr. Swan believed the future might be faced with some degree of confidence and hope. Speaking in one of the lecture theaters of a great university, whose long and splendid services to education has lately been commemorated, he could not but congratulate Scotland and the Scottish section of the society on the very advantageous position it occupied in that respect. In England and Ireland they were suffering acutely from dire educational neglect and destitution. They were giving to the classes at the bottom of the industrial ladder a disjointed smattering of miscellaneous science of no great value, though probably good so far as it went, while they were neglecting to thoroughly educate those upon whose shoulders would soon rest the weight of the management of the great manufacturing industries. A scientific training of university standard for our manufacturers and for our technical chiefs was an absolute necessity. One of the most pressing requirements of the moment, demanded not only in the interest of chemical industry, but in that of the manufacturing industries generally, was the adequate endowment and encouragement of research. The advances in knowledge, and the consequent revolutionary changes that had taken place in almost every branch of chemical industry during the last 100 years were probably not greater than those further changes that would be seen at the end of the present century, for change brought about by scientific discovery grew ever swifter and more sweeping. Change was the natural order of things; but, to take advantage of it, the fullest measure of assistance was demanded that education and energy could give.

Mr. W. H. Maw recently delivered his presidential address before the members of the British Institution of Mechanical Engineers. Dealing with the question of the education of young mechanical engineers, he said, according to the London *Times*, that nothing was more disheartening to a student than to find at some stage in his career that he had been devoting time to learning things which were not only useless to him, but which it was desirable he

should unlearn, while, on the other hand, he had failed to acquire knowledge of which he stood badly in need. Yet this was a far too frequent experience with boys entering technical colleges from the public schools. The remedial changes which had so far been made in this direction were limited in extent compared with those really required, and there was still left to be done at the technical college much educational work which ought to have been done at school, the result being a waste of valuable time. The matter was one which merited the most careful attention of all interested in technical education. There came a time when every engineer must specialize if he really wanted to attain anything more than a subordinate position. This specialization should be at least commenced during the college career rather than subsequently, the student devoting the latter part of his course at college to the acquirement of a knowledge of the special principles which underlay practice in the particular branch of the profession to which he was about to devote himself. This meant that the college authorities must take a wider view of their responsibilities than many of them did at present. It would also probably mean in the future that certain colleges would acquire a reputation for certain branches of work. One of the chief aims of technical college training should be to develop independent thought and action in a student. It could not be too thoroughly appreciated that the vast development of mechanical engineering work which had been going on in the past half-century, and which was still going on at an ever-increasing rate, was producing a most important change in the conditions which secured both professional and commercial success. In the old days the leading firms of mechanical engineers had comparatively few customers, and they had, as a rule, to meet the great variety of requirements of those customers to the best of their ability. Repetition work was comparatively rare, and success depended largely on resourcefulness and the power of entering thoroughly into the conditions to be fulfilled. Nowadays the successful mechanical engineer was not he who made a great variety of things for the few, but a small variety of things for the many, at the same time producing those few things in the most perfect way. Experience showed clearly that mere lowness of price was not in itself an inducement to purchasers, and the maker of an engine of exceptional economy or of a machine too, which excelled its competitors in the quantity or quality of the work it turned out would never find difficulty in obtaining proportionately good prices for his productions.

UNIVERSITY AND EDUCATIONAL NEWS.

BEREA COLLEGE, Ky., receives $50,000 by the will of Stephen Ballard, of Brooklyn.

THE Department of Agriculture has received a communication from the University of California announcing that a dairy school is to be established at that institution and requesting that a butter and cheese expert of the department be permitted to go to California to assist in establishing the school. Mr. W. E. Griffith, one of the experts of the department, will be assigned to this work August 20.

PRESIDENT JAMES WHITFORD BASHFORD, of Ohio Wesleyan University, has been offered the presidency of Northwestern University.

DR. T. D. WOOD, professor of hygiene and organic training at Stanford University, has accepted a similar position at Teachers College, Columbia University.

ELLIOT R. DOWNING, Ph.D. (Chicago), who has been during the summer assistant in zoology at Chicago University, will in the autumn take charge of the biological department at the Northern State Normal School at Marquette, Mich.

DR. CHARLES F. HOTTES has been appointed instructor in botany in the University of Illinois. Mr. Hottes was formerly assistant in the botanical laboratory of the University, but has spent the last three years at the University at Bonn, studying plant physiology and cytology. Mr. H. Hasselbring, of the New York Agricultural Experiment Station at Geneva, has been appointed assistant in the Agricultural Experiment Station of the same University.

DR. FLORENCE M. LYON, of Smith College, has been appointed associate in botany in the University of Chicago and dean of Beecher Hall.